Annual Report 1984

Bean Program

Centro Internacional de Agricultura Tropical

BEAN ANNUAL REPORT 1984

CONTENTS

HIGHLIGHTS 1984

The Bean Program has had an active year through 1984. It was the first year of operation without a senior staff vacancy since 1979. The physiology postdoctoral position was filled at the senior staff level, and the microbiology vacancy was filled at the postdoctoral level.

The achievements of the program can best be summarized by the conclusions reached at the International Trials Workshop conducted at the end of November. In this workshop, for the first time national program scientists were united from the network in Latin America, with those from the network in formation in eastern and southern Africa and the Middle East. A lively interchange of experiences, materials, methodologies etc. took place and a great step forward was made in the expansion of the network.

The conclusion was drawn that nearly all Latin American national programs have identified materials superior to commercial cultivars. There were, however, great differences among national programs in the success of promotion of the new technology to farmers. Guatemala, Costa Rica, Argentina and some states of Brazil have been successfull. Others much less so, and long discussions centered around the issue of promotion of new technology. The workshop concluded that increased on-farm testing involving extension agents (and seed production) was the challenge for the future. Alternatively, due to lack of on-farm research, (OFR), research scientists may have selected varieties which did not fit farmers' needs. The first OFR training course carried out in CIAT in 1984 (12 participants) and to be conducted in Peru in 1985 are timely events to respond to those needs. The simple farmers' questionaire developed by the Economics, and the OFR research sections in the Central American and Great Lake projects all are seen as additional ways to respond to identified needs.

Germplasm improvement remains one of the program's most important activities. The prime source for genetic variability is the gene bank, currently composed of 35,000 accessions, of which 19,303 have been increased. This year 1,865 accessions were added. The bank is an active resource for genetic variability for both national and international programs. This year, over 14,000 seed samples were shipped from the bank.

With an increasing number of bank entries used in genetic improvement programs and to efficiently store, retrieve and use information on crosses and derived lines an Integrated Data Management System (Relational), IDMS/R, is being developed. A database is sought which is as simple as possible. Currently, the detailed structure has been developed.

Character Development

Development of lines with BCMV non-I-gene, or protected I-gene resistance was greatly increased following network expansion into Africa, where the necrotic strains of BCMV are predominant. Well over a hundred lines which are blackroot resistant have been developed and several hundred individual plant selections made to rapidly solve this constraint to testing improved germplasm in many areas in Africa.

The EP is routinely evaluated for quality factors and large differences among the color groups have been apparent. The group of Central American reds has a problem of hard seed development, and the climbers are low in protein; on the average the small white-seeded lines are 3.5% higher in protein than the small red climbers. Studies are underway to determine the effect of the production environment on quality factors prior to initiating genetic improvement activities in this area.

With the naming of a postdoctoral scientist the level of research on nitrogen fixation was brought back to normal. While RIZ lines perform well in international trials, collaborative research with Rothamstead Experiment Station (Great Britain) on the N^{15} isotope dilution method was initiated. This research should provide information as to whether RIZ lines are outstanding because of increased N fixation or from other factors.

With the naming of the senior staff physiologist, much needed information on drought tolerance and yield potential is generated. It appears that the main mechanism of drought tolerance in CIAT-Palmira characterized by deep soils, is based on depth of rooting, a factor which does not occur in CIAT-Quilichao where high Al content in the subsoil, prevents deep rooting. Greatly increased emphasis was placed on the development of early maturing lines. The yield per day of early lines appears to be equal to that of late maturing lines, however, great variability among genotypes is observed. Lateness, not associated with problems of adaptation, has not yet been encountered in program germplasm.

The common bacterial blight (CBB) resistance derived from *P. acutifolius* in XAN 159, 160 and 161 is providing new and high levels of resistance used in varietal improvement. Resistance is additive, and may be based mainly on three recessive genes.

Character Deployment

The VEF-EP-IBYAN testing scheme further evolved through 1984. Currently, the VEF is mostly assembled from pre-VEF data (VA = Vivero de Adaptacion) collected by network scientists in the area for which the lines were bred. This scheme provides the national programs with more materials to test for local adaptation to climate, soil and disease pressure. Lines are coded after good performance in the target area and these lines form the VEF. The VEF therefore integrates these separate breeding efforts and provides further disease and insect resistance data. Similarly, the EP and IBYAN are partly assembled by national program scientists for some color groups. When national programs have received segregating populations their selections also enter the VEF.

The Latin American network has developed superior germplasm for promotion. Great progress has been made in the development of better and more stable colors for Central America. The challenge will be to develop a wider range of maturity in these materials, especially with respect to earliness. In other difficult color groups many improved lines are now available, such as large white's, yellow-grained Canarios and Azufrados, and Andean and African grain types.

Network Developments

The Great Lakes Project in Central Africa has passed its first full year of activity. Much superior germplasm was made available, and through the anthropologist a better understanding was developed of farmers'treatment of mixtures and how research can respond to them. The first line, ICA Palmar, now called Rubona 5, reached advanced stages of national testing in Rwanda. The project has also started to link with many development projects in the region.

Formal committment for funding was obtained for the East Africa project and the first scientist is stationed in Thika, Kenya. Following the genetic improvement of large, white-seeded types (Alubia) a nursery for West Asia, North African Adaptation of 95 selected lines was sent to seven countries in the region. The nursery was planted in five locations in Turkey and 16 lines are being multiplied for regional yield trials.

Adoption of New Technology

Through decentralized selection genetic improvement has been made more efficient. Many lines are currently in preliminary and regional yield testing. Again this year, new varieties were released (Table 1).

Previous varietal releases have in some cases resulted in farmers' adoption and large scale commercial use. In other cases, released varieties did not reach commercial importance. Detailed impact studies have shown that in Costa Rica, Guatemala and Argentina adoption rates of the new varieties by farmers are high.

Table 1. Varietal Releases in 1984

Country/ institution	Line	Name
Brazil		
EMGOPA	A 295	EMGOPA-201-ouro
EPABA	EMP 86	EPABA-1
PESAGRO	BAT 58	XODO
	BAT 873	Grande Rio
	BAT 904	Ipanema
	BAT 304	
		Capixaba precoce
Honduras		
SRN	US-104	Esperanza 4

THE PROGRAM

The objective of the Bean Program is to develop, in close collaboration with national programs, technology that will increase the production and productivity of beans.

The principal bean producer is a small farmer with limited capital and little access to credit and extension information. Bean yields are low and are stagnant in most countries. The main factors responsible for the low yields are: the high disease and insect pressure from which the crop suffers; drought; low plant density (to avoid disease pressure); and farmers' reluctance to use inputs to avoid risk or due to lack of access to these inputs.

Therefore, the bean team concluded, that it should prioritize breeding for more stable, higher-yielding beans, by developing multiple disease and pest resistance germplasm with increased tolerance to drought. Longer term objectives include: tolerance to moderately acid soils; improved genetic ability for symbiotic nitrogen fixation; and to increase yield potential. In summary, the bean team considers that the key to improved bean production is an improved variety. Once superior more stable yielding varieties are available, farmers are expected to respond with improved agronomy. The team develops scale neutral technology, possibly biased toward small farmers.

New bean varieties, not only must be superior yielders at the farm level, but also must have the proper seed size and seed coat color, and they must fit into farmers'production systems which often include maiz in direct association or relay cropping.

As the Bean Program must breed for many cropping systems and ecological zones, it is evident that a decentralized breeding program is needed in which national programs must play an important role in developing new varieties. This can only be achieved through a concentrated training effort. Hence training is the second most important activity after varietal improvement.

Genetic improvement activities are divided by production region (which automatically includes a separation by color and seed size groups, priority disease complexes, and often by cropping system). Therefore, while the Program breeds for a complex set of requirements as a whole, only a subset of production constraints is attended for each production region.

Genetic variability for specific traits in beans is generally not expressed at sufficiently high levels to solve production constraints. Therefore, each breeder, not only develops cultivars but also cooperates with particular disciplines to develop maximum levels of character improvement e.g., for bean golden mosaic virus (BGMV) resistance, drought tolerance, bacterial blight resistance, leafhopper tolerance, Ascochyta leafspot resistance, ability to fix nitrogen, high yield potential, architectural traits, etc. Lines with high levels of specific trait expressions are then used to obtain multiple factor recombinants in the cultivar improvement activities.

Once a newly developed line from the improvement program is found superior, and uniform in character expression, plant and grain type and maturity, and is resistant to BCMV, it enters the first uniform Evaluation Nursery - the VEF. In this nursery, approximately 1,000 entries are evaluated for disease and insect resistance and adaptation to the Palmira and Popayan environments. Superior entries may enter again into the crossing blocks as parents, move to national program nurseries and/or may pass to the second stage of evaluation the Preliminary Yield Nursery, EP, which typically contains about 300 entries. Disease resistance is confirmed in this nursery, and many other evaluations are made, including yield (under high and low input conditions in Palmira and Popayan), N-fixation ability, and seed quality evaluation. Specific evaluations for some characters are done outside Colombia. Part of the VEF and EP nurseries (with grain types of specific interest to a particular national program) is provided upon request.

Approximately 60 of the best lines of the EP advance to the International Bean Yield and Adaptation Nursery (IBYAN) to be evaluated worldwide. For each successive nursery, seed is produced in special plots under carefully controlled conditions to ensure that the seed is disease-free. The entries in each of the three nurseries are changed each year on January 1. National programs are encouraged to include their best hybrid lines in this open testing procedure, thus providing horizontal transfer of germplasm.

Before international shipment the seed health laboratory in the Genetic Resources Unit samples germplasm to ensure that it is free of seed-borne pathogens and viruses.

Following intensive training efforts the genetic improvement activities are increasingly decentralized. Currently, the VEF for many production areas is selected based upon evaluation of the VEF candidates in these areas. It provides national programs with much more material, and selection for local adaptation is exploited.

From the above philosophy and practice, it is clear that the Bean Program strongly emphasizes varietal improvement, and considers that improved agronomic practices are best researched at the national program level and should be implemented when a new variety is available. Instrumental in this concept are the cropping systems agronomist (on-farm research) and the economist, who insure that the breeders are familiar with the systems into which new varieties must fit. In addition, they adapt methodologies of on-farm research so that national programs

develop suitable agronomy around new varieties in specific regions.
in specific regions.

After genetic improvement, the program has given high priority to training. Self-reliance in research at the national level is the eventual goal. Furthermore, the diversity of cropping systems, production constraints and consumer requirements make it impossible for CIAT to attend all concerns. The results of training for self-reliance in research are becoming visible and show an evolution in the program's training strategy. For example:

(1) previously the VEF was exclusively a CIAT nursery, now it is often formed following selection at the pre-VEF stage in major production areas.
(2) Decentralized selection from the F_2 generation on, is becoming increasingly important.
(3) CIAT-hosted courses are being replaced by in-country courses.
(4) An on-farm research network is being developed through an intensive training effort.

The team expects that with postgraduate training, through leadership and experience, the national programs will develop to such a level that the network becomes a mutually dependent collaborative research program. This network has traditionally been limited to Latin America, however, since stationing the first bean scientist in Africa in 1983, network expansion to this continent has become an important objective. The first modest effort was initiated to include the Middle East in the bean research network.

I. Bean Germplasm Activities

1. Germplasm collection, multiplication, evaluation and distribution

a. Germplasm acquisition. Additional germplasm has been acquired from 21 countries through donations of national programs and from collecting expeditions funded by the IBPGR[a]. The number of materials introduced during 1984 totals 1576 accessions of *P. vulgaris* and 289 accessions of other *Phaseolus* species (Table 2). The collecting expedition efforts will continue with emphasis placed on wild ancestral and non-ancestral forms as well as on germplasm of the other cultivated species of the genus.

b. Status of the Phaseolus germplasm collection. The collection of *Phaseolus* has reached a total of 34,312 accessions (Table 3). Of these 89.0% corresponds to *P. vulgaris*, 7.0% to *P. lunatus*, 3.5% to *P. coccineus*, 0.6 % to *P. acutifolius* and 0.2% to wild non-cultivated species. Likewise, 55% of the total germplasm received so far has been increased and is available for distribution.

c. Description of the available P. vulgaris germplasm. To measure the genetic variability of the *P. vulgaris* germplasm and its geographical relationships, an intensive search has been done for information on where the germplasm originated of those materials already increased and held at CIAT. Both the donor country and the origin were compared with two important characters in common beans: seed size and growth habit.

The available data shows that North America, Central America and Europe are the major donors of germplasm totalling more than 76% of the accessions increased so far. However, when the origin[b] was considered, both North America and Europe accounted for only about 16% of the germplasm, while Central America and Andean South America appeared as the major contributors with a previous origin of about 54% of the common bean germplasm (Figure 1). This notorious change, particularly for Central America, may reflect the American origin of *Phaseolus* and its subsequent dispersion to other areas through germplasm exchange.

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[a] Appendix I lists associated centers and institutions.

[b] Origin, in *P. vulgaris* germplasm, refers (when possible) to where the materials have been bred or collected. In some instances that information is not traceable, therefore, the first known source is included.

Table 2. Germplasm introduced by the Genetic Resources Unit during 1984.

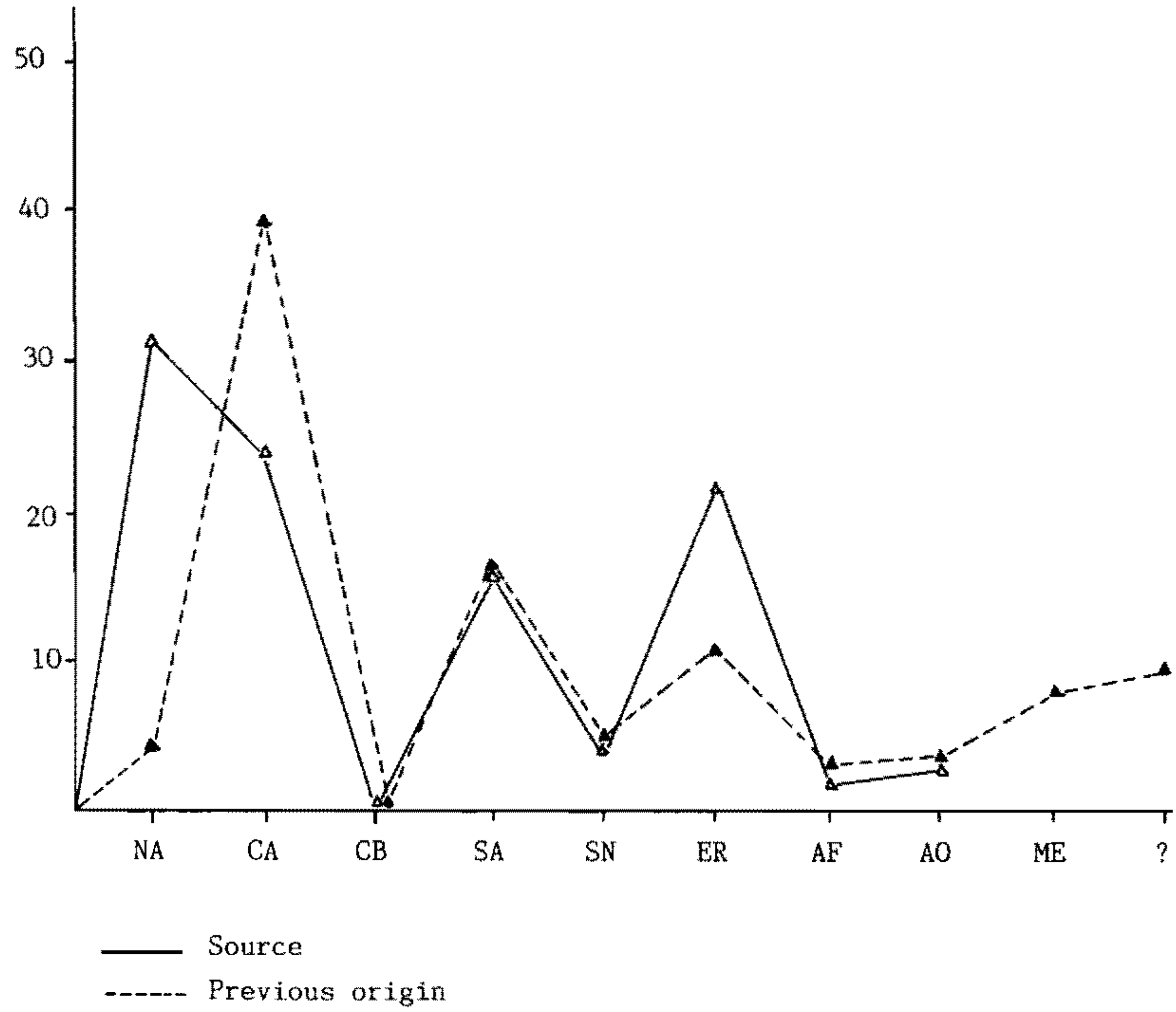
Country	No. of accessions *Phaseolus vulgaris*	Other *Phaseolus*
Belgium	6	6
Bhutan[a]	32	5
Brazil	177	55
Chile	29	-
Colombia	11	1
Costa Rica	273	165
Ecuador	13	-
Guatemala	13	-
New Guinea[a]	13	-
Holland	50	3
Hungary	100	-
Italy	72	1
Kenya[a]	72	-
Mexico	130	43
Nicaragua	1	-
Peru	134	6
Puerto Rico	5	-
Dominican Republic	2	-
United States	356	-
Zambia[a]	83	-
Zimbabwe[a]	4	4
Total	1576	289

[a] IBPGR collecting expeditons

Table 3. Status of the Bean Collection held at the CIAT Genetic Resources Unit as of December/84

Species	No. of accessions Introduced	Increased[a]
P. vulgaris	29,876	17,723
P. vulgaris wild ancestors	344	344
P. lunatus	2,527	655
P. lunatus wild ancestors	63	40
P. coccineus subsp. *coccineus*	779	234
P. coccineus subsp. *polyanthus*	400	96
P. coccineus wild ancestors	56	5
P. acutifolius	132	113
P. acutifolius wild ancestors	50	50
Wild non-cultivated *P. anisotrichus*, *P. filiformis*, *P. galactoides*, P. *microcarpus* *P. metcalfei*, *P. pedicellatus* *P. polystachius*, *P. parvulus*, *P. ritensis*, P. *wrightii*	85	34
TOTAL	34,312	19,303

[a] Available for distribution



NA = North America
CA = Central America
SA = South America Andean
SN = South America Non-Andean
ER = Europe

AF = Africa
AO = Asia - Oceania
ME = Middle East
? = Unknown

Figure 1. Comparison of the *P. vulgaris* germplasm source vs. its previous origin. (Available germplasm* as of December/84).

* 16769 accessions available. Wild ancestral forms not included.

Although CIAT has not yet directly received germplasm from the Middle East, this region is well represented (8.0%), however, the real origin of these materials is not known. There is no information at all on the previous or real origin of almost 9% of the P. vulgaris germplasm.

The above distribution suggests that a search for more detailed information on the real origin is needed to elucidate the truly secondary centers of diversity as well as to establish the path of germplasm exchange, so that future areas of collecting can be chosen more precisely. In the meantime, it appears that the Caribbean, non-Andean South America, Africa, Asia-Oceania and the Middle East regions have a low germplasm representation and perhaps collecting efforts need to be carried out in those regions.

Seed size. The proportion of the three seed size groups within the available germplasm of P. vulgaris (16,769 accessions) shows a similar proportion of 38% for small and medium-size seed while the large types appear with 24% (Figure 2B). The geographical distribution for origin of the three conventional seed sizes (small for less than 25g per 100 seeds, medium and large for over 40g per 100 seeds) shows that the small ones come mostly from Central America (53%) followed by Andean South America (13%). The other regions have a low representation. For the medium seed size (between 25 to 40 per 100 seeds) , again Central America appears as the major contributor (37%) while, Andean South America and Europe add up to almost 25%. (Figure 2B).

There is a substantial change in origin for large-seeded types. Andean South America provided 28% of the large-seeded types and has the highest representation, followed by Europe with 22% of the germplasm (Figure 2A). These results seem to be correlated with the geographical distribution of growth habits.

Growth habit. The percentages of growth habits (Figure 3) show the type III with the highest representation in the available germplasm with 36%, while type IV and type I show percentages between 22-26%; type II is the least frequent in this germplasm group with about 13%. The growth habit of 3% of the materials has not been recorded possibly due to adaptation problems (Figure 3A). The geographical distribution for origin of types shows that Europe has been the highest contributor of type I (33%), followed by Andean South America (13%); there is a similar percentage of materials with unknown origin. Central America also has some representation of the type I (10%) (Figure 3B).

For type II, Central America is the major contributor for origin (with about 50%) while Andean and non-Andean South America add up to 31%. Type II seems to be derived exclusively from these regions since the percentages of other regions are very low except for the unknown ones. Type III has a similar distribution as type II, in which Central America is again the major provider (47%) for origin, however, the Middle East provides an appreciable percentage (10%) of this type.

The major contributors for the climbing type IV are Central America with 43% of the total germplasm, followed by Andean South America with 16%. Surprisingly, the Middle East and Europe provided rather high percentages (7-8%) of this growth habit.

By combining the information on geographical distribution of seed size and growth habit the possibility is suggested that the large-seeded types have two main sources; type I coming from Europe and Andean South America, and type IV coming from Andean South America. The small and medium-seeded types apparently are II´s and III´s from Central America. Some of medium size accessions of type I may come from Europe.

These general conclusions need further confirmation when seed coat color will be taken into account and more information on the real origin is gathered. With these morpho-agronomic data the definition of the truly secondary centers of diversification of the species and of the genus will be more readily discernible.

d. Other species of Phaseolus. Through the increase of the *P. coccineus* collection in mesh cages more than 200 accessions have been processed. Likewise, a more intensive characterization- evaluation has been started in the the pursuit of germplasm with resistances to the main limiting pests and diseases of *P. vulgaris* so that breeders can use them in their crossing schemes. This characterization-evaluation is being carried out in cooperation with the University of Gembloux.

A complete characterization of most of the *P. acutifolius* collection (166 accessions) is underway at two locations (at 800 and 1000 msl). It includes both the cultivated forms and the wild ancestral types. This study will identify most of the genetic variability available in this species.

The *P. lunatus* germplasm, is only being increased and assembled. A project to characterize this collection is planned for the near future. In the process of increasing the collection some adaptation data have already been taken which help in the selection of materials for distribution.

e. Seed distribution. Attending the requests for germplasm continues as a dynamic activity during 1984. A total of 41 requests from 27 countries were received, adding up to a total of 2229 accessions distributed. Likewise, a total of 11,995 accessions were supplied to the Bean Program this year (Table 4).

Table 4. *Phaseolus* bean seed distribution by destination during 1984

Destination	Countries	No. of accessions
Outside CIAT		
North America	USA, Canada	67
Central America	Nicaragua, Guatemala, Mexico, Honduras,	1,722
Caribbean	Cuba, Haiti, Dominican Republic	112
Andean South America	Venezuela, Chile, Peru, Colombia, Ecuador	120
Non-Andean South America	Argentina, Brazil	65
Europe	England, Holland, Bulgaria France, Spain, Germany	103
Asia - Oceania	Philippines, Australia, Japan, China, Burma	40
Sub-total	27	2,229
CIAT Bean Team		11,995
TOTAL		14,224

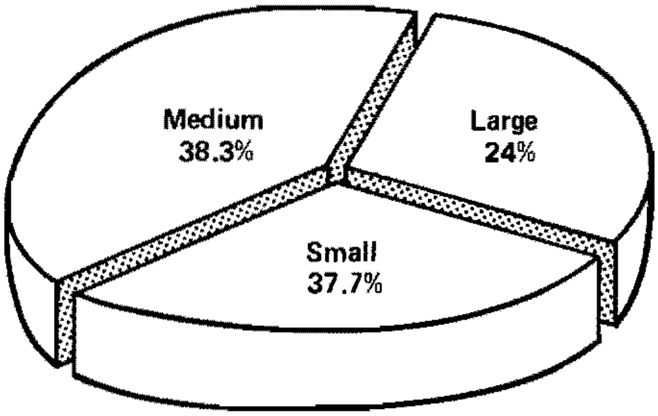


Figure 2A. Distribution of seed size within the available *P. vulgaris* germplasm. (16769 accessions, as of Dec./84).

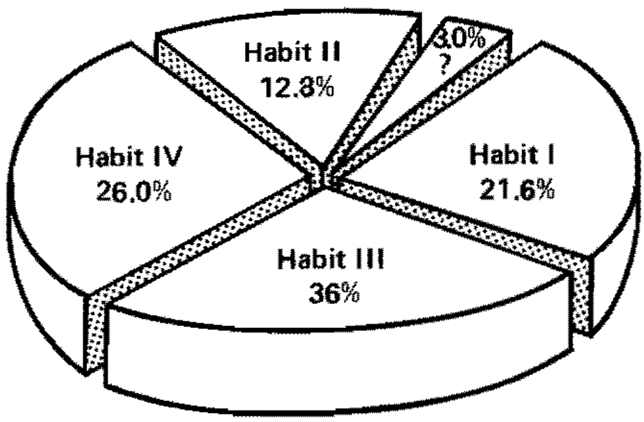


Figure 3A. Distribution of the growth habits within the available *P. vulgaris* germplasm (16769 accessions, as of Dec./84).

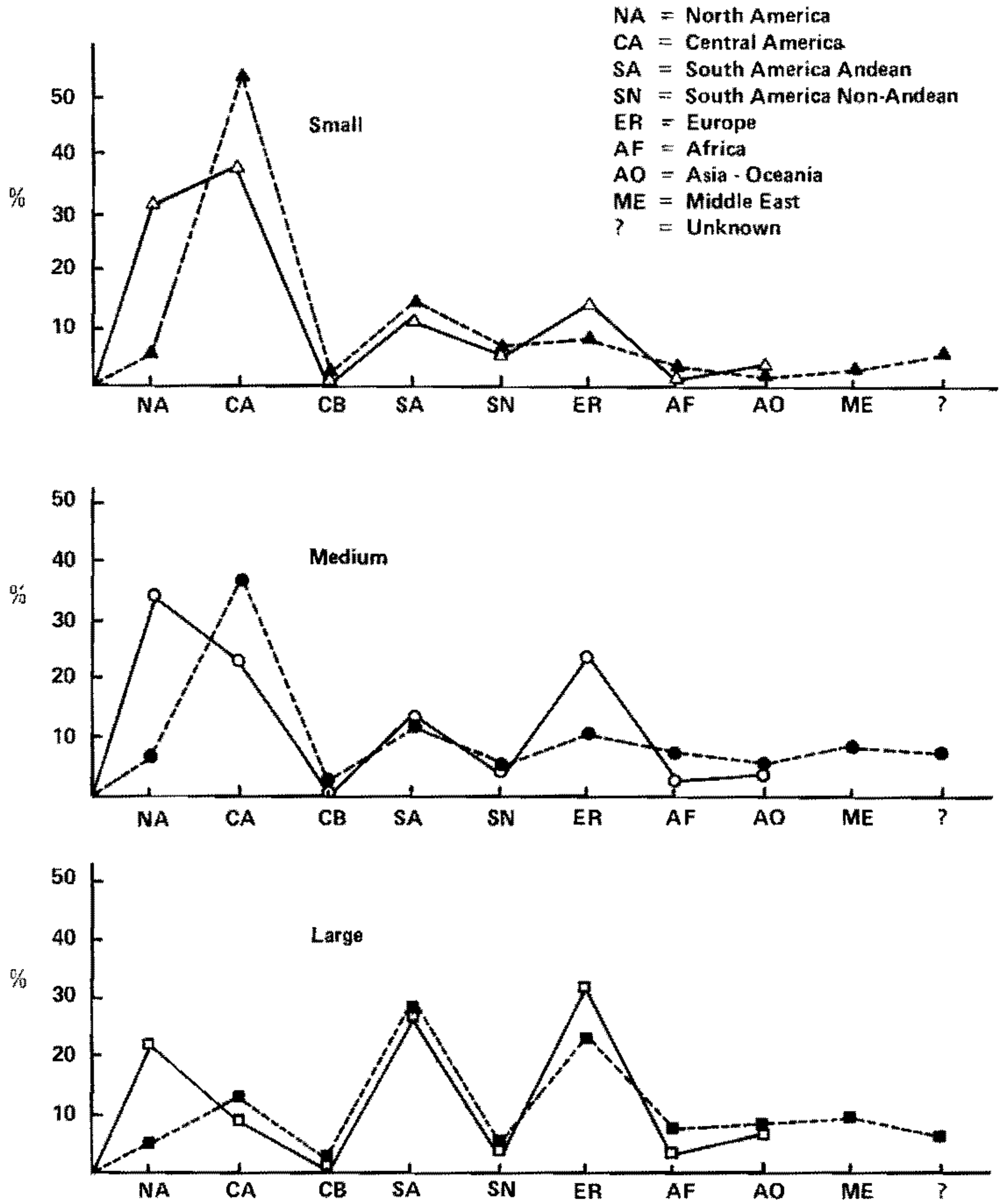


Figure 2B. Comparison of germplasm source vs. Previous origin of three seed sizes. (Available germplasm as of December/84).

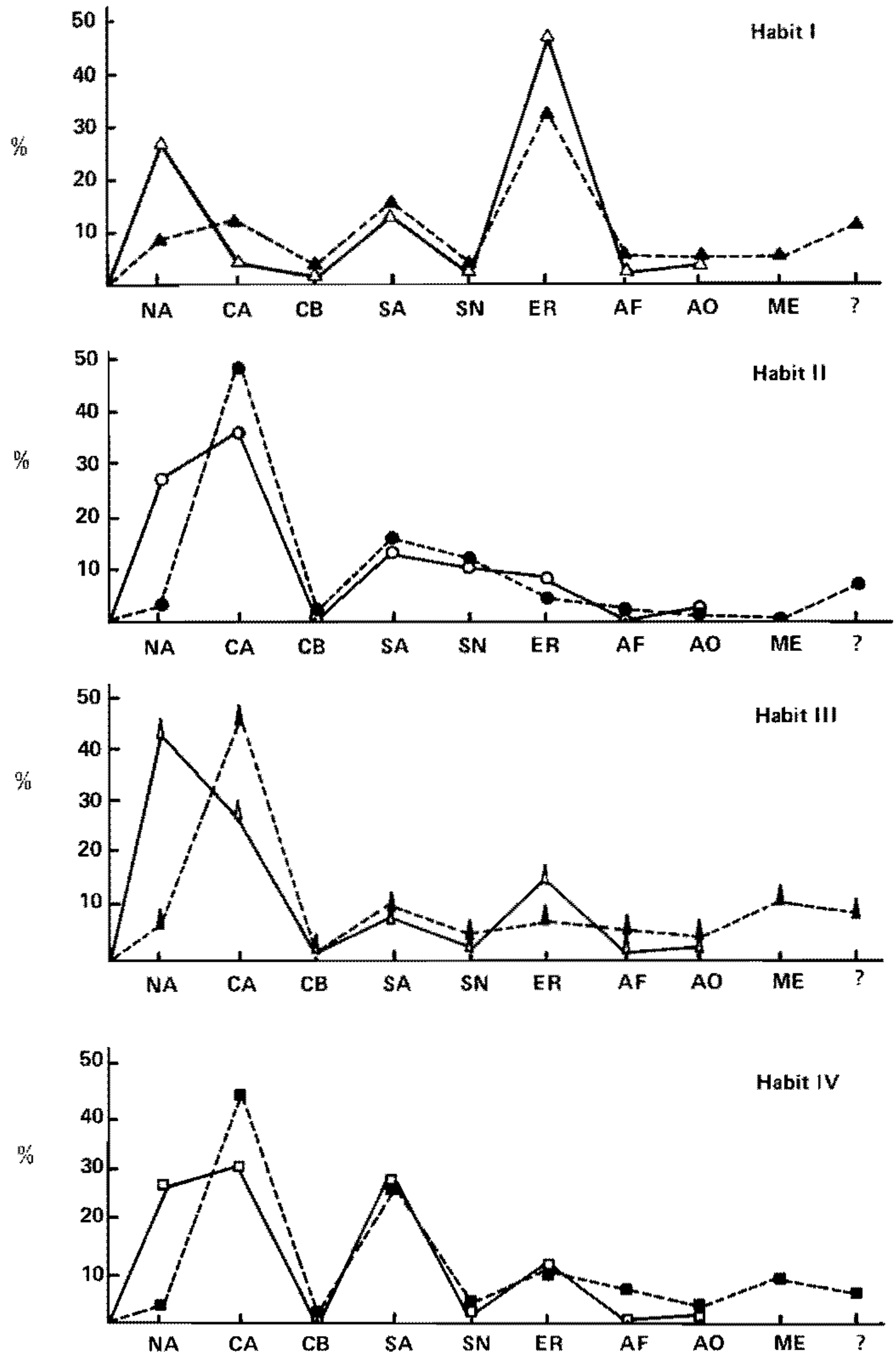


Figure 3B. Comparison of germplasm source vs. Previous origin of four growth habits. (Available germplasm as of December/84).

2. Germplasm Data Management

In January 1984, a project was begun to improve the management of data for the Bean Program and the Genetic Resources Unit. Previously, data were processed with a series of programs written in SAS and FORTRAN. However, these programs proved to be inadequate for the great numbers of trials and accessions, and consequently the amount of data from various sources that the Bean Program handles. Because of a lack of standardization, integration and centralization, files of data were widely scattered and contained numerous inconsistencies. Therefore, processing data, retrieving information and printing reports were difficult, time-consuming tasks.

To overcome these problems, a data management system operating with a centralized database was needed. Data management systems are designed to facilitate : (a) the detection of errors; (b) the enforcement of standards for both the format and the processing of data; and (c) the retrieval of data in diverse formats. A central database on the mainframe IBM 4331 computer was needed, rather than a system based on microcomputers, because, with a micro-based system, data would be scattered just as widely as before. The collation of data for producing reports etc. would therefore be just as slow and difficult. However, there was also a need for integration of the central database with microcomputers, primarily for outposted scientists, who do not have direct access to the central database.

The system chosen was IDMS/R (Integrated Data Management System (Relational), produced by Cullinet Software Inc. Two of the principal advantages for the bean program of this sytem over others are: (a) it does not suffer so much degradation of performance as other systems when large amounts of data are involved; and (b) full integration between microcomputers and the central database on the mainframe is built into the system.

The following objectives were defined at the start of the project.

1. An IDMS/R database should be designed and set up on the mainframe as a central repository for all data on beans.
2. The system developed should initially be as simple as possible. Refinements would be added later, once the system has proven useful.
3. Existing data should be standardized and corrected so that they could be included in the database.
4. The system should facilitate the Data Services Unit's task of managing data for the bean program, entering data into the database and constructing field books, reports and catalogues.

5. The system should enable members of the Bean Program themselves to interrogate and modify the database.

After analysing the needs of the Bean Program, it was decided that the database would initially contain data only for :

1. the characterisation of accessions, and
2. the origins of accessions.

Accessions are characterized in terms of their phenotype, genotype, and other classification systems (e.g. taxonomic, commercial type, grain type, common name etc). Phenotype varies with environment as well as with genotype, and may be scored for an accession in any experiment in which the accession was grown. Table 5 shows the approximate number of different phenotype characteristics that may be scored by members of the Bean Program or Genetic Resources Unit.

The database would not contain;

1. an inventory of the stocks and status of accessions held by the Genetic Resources Unit or by the bean program, or
2. any agroecological data needed for analysing the stability of lines or the variability of pathogens.

The Cassava Program is developing an inventory under IDMS/R, and the Agroecological Unit is developing an agroecological database. It is possible that both databases could, at some later date, be combined with the bean database. Of course only the design, not the data, of the cassava inventory would be incorporated, while both the design and the data of the agroecological database would be included.

After the detailed structure of the database had been fully defined on the computer, the following order of priorities were set up for entering data and writing programs to process the database.

1. Basic identification of all accessions.
2. VEF and EP trials.
3. Crossing blocks, nurseries of segregating populations, pedigrees and genealogies.
4. Genetic Resources Unit passport data base other than those included in 1.
5. GRU characterization data.
6. Other trials. International nurseries? On farm trials?

Table 5. Illustration of types of data used to evaluate the phenotypes of accessions, and the approximate number of characteristics recorded by the bean team.

type of measurement	N° of characteristics describin : Responde to pathogen	Other phenotypic characteristics
Qualitative 1-9 score 1 = best, 9 worst e.g. for adaptation	62	3
Qualitative groups No best e.g. for growth habit, flower color		12
Quantitative e.g. for yield		43
TOTAL	62	58

3. Genetic Improvement

Germplasm improvement activities of the Bean Program are based upon the arge variability in the germplasm collection stored at CIAT. In the evaluation of the germplasm bank useful traits are identified with the potential to solve or reduce the effect of production-limiting factors. However, in many instances the level of expression of desirable traits in germplasm bank accesions is insufficient to solve particular production constraints; e. g., the level of resistance to bean golden mosaic virus (BGMV), Ascochyta leafspot, drought tolerance, resistance to storage insects, ability to fix atmospheric nitrogen, etc. For the improvement of commercial varieties combinations of several of these factors are needed. Combinations of characters are needed according to the production problems and consumer requirements for each ecological production zone. Therefore genetic improvement activities of the Bean Program can be divided into two aspects : (a) character improvement - the development of maximal expression of a character in a diversity of genotypes by accumulating different gener, resistance mechanisms, etc.; and (b) character deployment - the recombination or use of these characters in commercial cultivars according to the needs of the particular production region for which the material is intended. In this activity commercial local cultivars are heavily used in crossing to ensure local adaptation in progenies.

Table 6 lists the specific responsibilities of the three breeders in these two activities, the numbers of crosses made during 1984, and the number of coded lines developed, and submitted to the VEF/85.

Table 6. Specific responsibilites No. of crossesmade and lines codes by the three breeders in the CIAT Bean Program for character improvement and deployment projects in 1984.

Research area	Responsible breeding program			No. of crosses	No. of coded lines to VEF 85
<u>Character improvement</u>					
Bean common mosaic virus	I			35	33
Bean golden mosaic virus	I			29	68
Rust	I			10	-
Common bacterial blight	I			45	21
Halo blight			III	61	6
Web blight	I			30	9
Anthracnose		II		45	-
Angular leaf spot		II		84	-
<u>Asochyta</u> leaf spot			III	20	7
Mildew			III	-	-
Bean scab			III	-	-
<u>Empoasca</u> leafhoppers	I			38	27
<u>Apion</u> pod weevil	I			-	18
Storage insects			III	17	10
Bean fly			III	37	-
Mexican bean beetle		II		-	-
Nematodes			III	20	-
Drought		II		-	-
Temperature/photoper.			III	57	2
Low P		II		40	-
Maturity		II		92	-
N_2 fixation	I			-	24
Architecture		II		29	-
Yield potential				80	-
Snap beans			III	103	250
<u>Character deployment</u>					
Black beans	I			331	12
Central America	I			266	68
Caribbean	I			279	58
Coastal Mexico, Peru	I			520	103
Other studies	I			26	9
Brazil (non-black)		II		245	700[a]
Mexican highlands		II		228	400[a]
Argentina/W. Asia		II		180	21
Andean Zone			III	547	376
Africa			III	669	240
TOTAL				4,163	2,462

[a] Uncoded lines submitted for local selection end codding.

3.1. Character Improvement

a. Resistance to Fungal Diseases. In 1984, most of the pathology efforts were dedicated to the evaluation of bean germplasm for their reaction to the principal bean pathogens under field conditions in several locations throughout many of the bean growing areas. Even though some disease resistance nurseries were sent to Africa, most of the evaluations were conducted in Latin America. High priority was given to the most widespread and economically important bean diseases such as anthracnose, rust, angular leafspot and web blight.

Web blight was previously considered only of local economic importance in the hot and humid lowland tropical areas; however, last year it occurred in epidemic proportions in Argentina and other areas. In the last few years, this disease has also caused severe damage to beans grown in the coffee zone of Colombia. Other locally important diseases emphasized were halo blight and Ascochyta blight. In some bean growing areas, such as the highlands of Mexico, the germplasm accessions and lines were also evaluated for their reaction to round leaf spot and Phytophtora, diseases that are not traditionally known to be economically important but have caused considerable damage to susceptible germplasm over the last two years. Similar evaluations were also conducted for white mold in Argentina.

During 1984, the germplasm evaluated included several international bean nurseries : International Bean Rust Nursery (IBRN); International Bean Anthracnose Test (IBAT); Bean Angular Leaf Spot International Test (BALSIT); International Bean Common Bacterial Blight Nursery (VIB); and the International Bean Web Blight Nursery (VIM). The principal objective common to all international nurseries is the identification of sources of genetic resistance. For highly variable pathogens such as those that cause rust, anthracnose and angular leaf spot, for example, the emphasis is the identification of germplasm with resistance to the widest spectrum of the pathogenic potential in the population of a given pathogen. (Germplasm with specific resistance is also identified.)

Another important objective of the nurseries is to gather information about the stability of the different disease resistance mechanisms available such as pustule size in the case of rust. A third objective, particularly for highly variable pathogens, is to detect the possible appearence of a new race or pathogen population that can attack previously resistant lines and to prevent the extensive dissemination of a susceptible variety. The international nurseries also provide relevant information about the composition of the pathogen population and allow the comparison of the reaction of bean germplasm from one area to another to identify germplasm with wide resistance.

In addition to the international bean disease nurseries, other bean program germplasm and breeding progenies were routinely evaluated either in specific breeding projects or in advanced nurseries both in Colombia and other areas of Latin America and in close collaboration with bean scientists from national programs. Bean nurseries evaluated include : the Bean Adaptation Nurseries (VA) for specific target areas; as well as the first Bean Team Uniform Nursery (VEF); the Preliminary Yield Trials (EP) and the International Bean Yield and Adaptation Nursery (IBYAN). National program bean nurseries were also evaluated. Most of the advanced germplasm was simultaneously evaluated for disease reaction, local adaptation, reaction to other constraints and agronomic characters with the objective of identifying germplasm with multiple disease resistance that can be utilized either as a disease resistance source or as a commercial variety.

Similarly, bean germplasm accessions and lines were evaluated in the greenhouse for their reaction to the rust, anthracnose, angular leaf spot, halo blight and common bacterial blight pathogens to study the pathogenic variation existing among the populations of bean pathogens, disease resistance mechanisms and basic studies in bean pathology.

Rust. The emphasis in rust (which is caused by *Uromyces phaseoli*) continues to be the identification of germplasm resistant to the broadest spectrum of the pathogen populations and the incorporation of resistance into germplasm having commercial grain color. Most of the accessions identified as having broad resistance to this highly variable pathogen come from the IBRN and have been evaluated for many years in many locations (see Bean Program Annual Report, 1982). During 1983-1984, the IBRN was distributed to 19 countries in Latin America and Africa. Table 7 shows some of the most resistant materials from the IBRN 83/84 evaluated in six locations in five countries. Many of these entries also had a resistant or intermediate rust reaction in previous years.

The IBRN, as well as any other bean germplasm evaluated for rust reaction under field conditions, is inoculated with a mixture of local isolates to select only germplasm with broad resistance. The population of the rust pathogen is highly variable and often rather specific. Table 8 shows the reaction of some bean lines to a rust isolate that attacks mostly snap beans but not dry beans and a dry bean isolate that can attack both. Both isolates are from the Cauca Valley of Colombia.

When inoculating bean germplasm for their reaction in the field, some entries display large pustule types surrounded by chlorotic halos while others have minute to very small pustules without the chlorotic halo. In order to study under greenhouse conditions the differences between varieties with large and small pustule types, four varieties were chosen; two with small, and two with large pustule types. Table 9 shows that BAT 93 and BAT 308 in addition to small rust pustules also have a longer latent period (time from inoculation to when 50% of lesions begin sporulation). They showed less rust severity and produced fewer spores per plant than the large pustule type varieties BAT 883 and Blue Lake Ferry. Under field conditions, varieties with large pustule types are generally severely attacked, appear as susceptible to the naked eye and suffer considerable reduction in yield. Varieties with small pustules, on the other hand, do not appear severely attacked, even though they may have a large number of pustules present on the foliage, and do not suffer considerable yield reductions (Table 10 and Bean Program Annual Report, 1981).

Angular leaf spot. During 1984, the Bean Angular Leaf Spot International Test (BALSIT) was distributed to several locations in Latin America and Africa. Field evaluations strongly suggest that the angular leaf spot pathogen is highly variable. Table 11 shows the reaction of the cultivar BAT 332 that has either an immune reaction or presents little disease in Colombia, but, is severely attacked in several locations of Brazil. This cultivar has a similar susceptible reaction in Argentina (not shown). Most cultivars show at least some symptoms in most locations where they have been evaluated and many have a resistant to moderately resistant reaction in one location but are susceptible in another. However, many of the cultivars with a resistant reaction in one or more locations in Brazil are also resistant in Popayan, Colombia. They include : A 75, A 339, A 210, A 211, A 247, A 338, A 301, A 152, A 175, A 195, A 240, A 294, A 299, A 382, BAT 21, BAT 67, BAT 76, BAT 1510, BAT 1432, BAT 1458, BAT 1647, G 2005, Jalo EEP 558, G 2959, G 3884, G 4421 and G 5653.

In addition to the evaluation of advanced uniform bean nurseries and segregating materials for their reaction to ALS, 643 cultivars known to have an intermediate or resistant reaction in one or more locations, were evaluated in Popayan. During the first evaluation 227 cultivars were selected for their ALS reaction and out of these 103 cultivars were selected for the BALSIT/85.

To elucidate the best inoculum concentration and bean plant age for ALS resistance screening several experiments were conducted under field conditions in Popayan. The results suggest that most cultivars do not develop disease symptoms before the plants are about 30 days old, however, symptoms appear to increase dramatically afterwards on both uninoculated and inoculated plants. The inoculum concentration does not appear to be as important as plant age in symptom expression and development (Table 12).

Research is also being conducted to study the effect of ALS date of initiation, severity of symptoms on foliage and pods and amount of defoliation by ALS on yield, number of pods per plant, and on seed size, shape and 100-seed weight. The varieties used are the highly susceptible G 2858, the moderately resistant A 285 and the moderately susceptible A 321 , all three in inoculated, natural infestation and chemically-protected treatments.

Anthracnose. The International Bean Anthracnose Test (IBAT) is evaluated in locations where anthracnose is an important disease. Much of the research done on anthracnose during 1984 concentrated on the evaluation of advanced uniform nurseries (VEF, EP) in Colombia, adaptation nurseries in the target area, and the evaluation of IBAT and other bean germplasm to identify other sources of resistance. Because of the advances made in the identification of new and better sources of anthracnose resistance in previous years (Bean Program Annual Report 1981, 1982 and 1983), the current emphasis is on the identification of anthracnose resistance sources with other desirable characters such as commercial grain color and resistance to other diseases and production constraints.

Table 13 shows the reaction of selected anthracnose-resistant cultivars from the IBAT in the Mexican Highlands where anthracnose is an important disease. Many of these cultivars such as G 2333, G 2338, A 262, A 321, A 262, AB 136, A 483 are also anthracnose resistant under field conditions in the provinces of Tucuman and Salta in Argentina; despite the fact that the pathogenic variation of the anthracnose fungus, *Colletotrichum lindemuthianum* is broad and different from one location to another. In Table 14 which shows the reaction of some bean cultivars under greenhouse conditions to some of the anthracnose pathogen isolates from Argentina, it is clear that isolates from the province of Santiago del Estero are different in pathogenicity from those of the provinces of Salta and Tucuman.

Because of the extensive pathogenic variation of the anthracnose fungus, the emphasis continues on: (1) the identification of new and better sources of resistance: (2) the incorporation of anthracnose resistance into cultivars with commercial grain color; (3) studies in pathogenic variation and the implication of it on breeding beans for anthracnose resistance; (4) and the study of disease resistance mechanisms and their stability.

Web blight. Research and screening for resistance to web blight is conducted in Central America (see section 5.2) (primarily in Costa Rica) with additional testing and selection in Colombia. Multilocation tests confirmed the levels of resistance in Costa Rican and Colombian selections reported in 1983. It is probable that current levels of resistance are adequate for the disease pressure of Panama and the coffee-growing region of Colombia, but are inadequate for the coastal lowlands of Central America.

The international web blight nursery (VIM) is being tested in areas of Peru and Brazil where the disease is an important limiting factor. Hybrid progenies are being evaluated in Costa Rica, Guatemala, Peru, Panama, Brazil and Colombia. Crosses among lines with intermediate levels of resistance were made to obtain higher resistance through transgressive segregation (Table 2, see Genetic Improvement section).

In addition to the ongoing web blight breeding program, the germplasm bank has been continuously evaluated in the search for sources of new resistance genes. Some 780 accessions were planted at the ICA-Turipana station in Colombia in May. Under heavy and uniform disease pressure 10 entries were identified as promising enough to merit further evaluation (Table 15). For the second planting season, germplasm was evaluated both in Turipana and in the experimental station of CENICAFE in Armenia (coffee production zone of Colombia). Seven promising lines were identified at Turipana, but none were superior to the intermediate check variety Talamanca (Table 15).

A number of promising lines from the germplasm bank and from CIAT hybridization programs were rated as intermediate or resistant in the test at Armenia under less severe disease pressure (Table 16). Some lines showed better resistance than the Talamanca check, and will be reevaluated as possible candidates for the international web blight nursery (VIM).

Results from evaluating the 1984 VIM in Turipana and Armenia are presented in Table 17. Some lines vary in their reaction to the pathogen according to the level of disease pressure, while others, including the check varieties BAT 1297, Talamanca, BAT 1155, and Calima, are more consistent. The use of such checks has greatly facilitated the identification of superior lines from the germplasm collection and from the crossing program.

b. Resistance to Bacterial Diseases

Halo blight. During 1984 a collaborative research effort between CIAT and the National Vegetable Research Station from Wellesbourne, England, was started to broaden the knowledge of halo blight of beans caused by *Pseudomonas phaseolicola* (= *P. syringae* pv. *phaseolicola*). The first activity planned was the collection of isolates of the halo blight pathogen from bean growing areas of Latin America and Africa, the preliminary identification based on cultural characters and the specific identification based on fluorescence, serology and phage tests. This work as well as the pathogenicity tests under greenhouse conditions were conducted in Wellesbourne.

Results of the first pathogenicity tests show the apparent occurrence of unknown variability in pathogenicity of *P. phaseolicola* different from the known races 2 and 3 (Table 18). These different isolates are from Africa and do not attack the Northamerican cultivars Tendergreen and Cascade, instead they elicit a strong hypersensitive reaction on the cultivars. Both, Tendergreen and Cascade are susceptible to races 1 and 2. It is worth noting on Table 9 the reaction of PI 150414 that varies from a highly resistant reaction (race specific or qualitative resistance) to isolates of the races 1 and 2, to a slightly resistant reaction (race non-specific or quantitative resistance) to the isolates from Africa belonging to race 3.

During the first semester of 1983, 230 cultivars were artificially inoculated and evaluated for their reaction to halo blight under field conditions in Popayan. Of these, 147 were selected as resistant and 55 as intermediate and were planted again for further evaluation. Many of these cultivars were originally selected in Pasto where the halo blight pathogen occurs naturally and causes severe damage to susceptible cultivars.

Table 7. Selected bean lines and varieties from the IBRN 83/84 with a resistant or intermediate rust reaction in six locations in five countries.

Identification	Rust reaction[a]			
	Immune	Resistant	Intermediate	Susceptible
Redlands Green Leaf B	0	5	4	0
Redlands Green Leaf C	1	4	4	0
Redlands Pioneer	1	7	1	0
Cuilapa 72	2	4	3	0
Ecuador 299	1	4	4	0
Mexico 235	1	4	4	0
mexico 309	4	3	2	0
BAT 76	4	3	2	0
BAT 93	4	1	3	0
BAT 260	2	3	4	0
BAT 308	3	6	0	0
BAT 520	3	3	3	0
EMP 81	2	4	3	0
XAN 97	3	5	1	0
G 1098	6	2	1	0
A 155	2	4	3	0
A 493	3	5	1	0

[a] Locations : Beltsville, Maryland, Fargo, North Dakota and North Plate, Nebraska, USA; Isabela, Puerto Rico; San Juan de las Maguana, Dominican Republic; Delmas, South Africa; Palmira, Colombia, 1983 A and B and 1984A.

Table 8. Comparison of the reaction of four bean cultivars to one isolate of *Uromyces phaseoli* from snap beans with an isolate from dry beans.

Cultivar	Bean type	Pustule type and severity (%)[a]	
		CIAT[b]	Pradera[b]
Blue Lake Ferry	Snap bean	5-30	5-50
BAT 883	Dry bean	5-25	NR
BAT 308	Dry bean	3-6	NR
EMP 81	Dry bean	NR	NR

[a] Lesion type : NR = no reaction, immune; 3 = intermediate size pustules 300 u in diameter; 5 = large pustules, more than 500 u in diameter.

[b] CIAT = rust isolate from dry beans; Pradera = isolate from snap beans.

Table 9. Differences in disease efficiency, latent period, severity and amount of <u>Uromyces phaseoli</u> uredospores produced between two bean varieties with a large pustule type, and two with a small pustule type.

Variety or line	Lesion[a] type	Disease[b] efficiency (o/ooo)	Latent period (days)	Severity (%)	Uredospores (mgr/plant)
BAT 883	5	20	7	50	8.38
Blue Lake Ferry	5	8	7	25	7.56
BAT 93	3	4	9	1	0.68
BAT 308	2,3	2	10	1	0.20

[a] Lesion type : 5= very large pustules surrounded by a chlorotic halo; 2 and 3= very small and small lesions, respectively, without a chlorotic halo.

[b] Disease efficiency = number of lesions formed following inoculation with the same number (1000) of spores. In all cases, mean obtained from five replications with five plants/replication.

Table 10. Comparison of the area under disease progress curve (AUDPC) and yield between protected and inoculated treatments for four bean cultivars differing in rust pustule type.

Identification	Type	Inoculated	Protected	Inoculated	Protected	Difference (%)
Ex Rico 23	5.4	1280.0	26	471.2	1199.4	60.7 a*
BAT 883	5.4	1172.5	32	660.6	1626.1	59.4 a
BAT 308	2.3	39.7	0	818.4	1109.4	26.2 b
EMP 81	2.3	125.8	0	814.5	1117.8	27.1 b

[a] Pustule type : 4 and 5 = large and very large pustules surrounded by chlorotic halos; 2 and 3 = very small and small pustules without chlorotic halo.

* The figures in the same column followed by the same letter were not significantly different at the P = 0.05 level of Duncan's Multiple Range Test.

Table 11. Selected bean lines and their reaction (on a 1-5 scale where 1 is free of symptoms and 5 is severely attacked) to the angular leaf spot pathogen *Isariopsis griseola* in several locations.

Identification	Capivara[a], Brazil	Anapolis, Brazil	Caruaru, Brazil	Rwanda	Popayan, Colombia
BAT 67	3.0	-	2.5	2.0	2.5
BAT 76	3.0	-	2.5	1.5	2.5
BAT 332	5.0	-	4.0	2.0	1.0
A 53	2.0	1.5	3.0	-	3.0
A 210	4.0	3.0	-	3.0	1.5
A 301	4.5	2.0	4.0	-	2.0
A 338	2.5	1.5	3.0	1.5	2.0

[a] Angular leaf spot reaction on a 1-5 scale where 1 is free of symptoms and 5 is severely attacked.

Table 12. Reaction of six bean cultivars inoculated once 15, 30 and 45 days after planting (AP) with 10, 20, 40 and 80 x 10^3 spores/ml of *Isariopsis griseola*[a], the angular leaf spot pathogen.

Cultivar	15 days AP[a]				30 days AP				40 days AP				30 days AP			
	NO	20	40	80	NO	20	40	80	NO	20	40	80	NO	20	40	80
BAT 76	1.5	1.0	1.0	2.0	1.5	2.0	1.5		1.5	2.0	2.0	2.0	1.5	1.5	1.5	1.5
A 212	1.0	1.0	1.5	1.5	1.5	2.0	1.5		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
A 285	1.5	2.5	2.5	2.5	1.0	2.0	2.0		2.5	2.0	2.0	2.0	1.5	2.5	2.0	2.0
A 252	2.0	3.0	2.5	3.0	2.5	3.0	2.5		2.5	3.0	3.0	3.0	3.0	3.5	3.0	3.0
A 321	2.5	2.0	2.0	3.0	3.5	3.0	3.5		3.0	3.5	3.5	3.0	4.0	4.0	4.0	4.0
G 2858	2.0	3.0	3.0	3.0	3.5	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.5	4.0	4.5

[a] The evaluation was conducted 12 days after each inoculation : 27, 42 and 57 days after planting for the first three groups. The last group was inoculated 30 days AP and evaluated 35 days later.
ALS reaction : 1 = no symptoms; 5 = severely diseased.

Table 13. Selected bean cultivars from the International Bean Anthracnose Test (IBAT) and their scores for anthracnose local adaptation and other constraints in some mexican states.

Cultivar	Growth habit	Calera, Zacatecas			Tepatitlan, Jalisco		
		Anthracnose	Halo blight	Adaptation	Anthracnose	Round leaf spot	Adaptation
G 811	III	1.0	1.0	5.0	1.0	2.5	4.5
G 2333	IV	1.0	1.0	5.0	1.0	3.5	4.5
G 2338	IV	1.0	1.0	5.0	1.0	1.0	5.0
G 6342	III	1.0	1.0	4.5	1.0	2.0	3.0
A 262	III	1.0	1.0	4.0	1.0	4.0	4.0
A 321	III	1.5	1.0	4.5	1.0	3.0	3.0
A 360	I	1.0	1.0	4.0	1.0	4.5	3.5
A 483	II	1.0	1.0	4.0	1.0	4.5	4.5
Kaboon	I	1.0	2.0	4.0	1.0	4.5	3.5
A 328 (Check)	II	4.5	1.0	4.5	3.5	4.0	4.0

Table 14. Reaction of several (bean) cultivars to several isolates of *Colletotrichum lindemuthianum* from three bean-growing provinces of Argentina [demonstrating (showery) pathogenic variation].

Cultivar	Province and isolate(s)				
	Salta		Tucuman	Santiago del Estero	
	Arg. 1	Arg. 13	Arg. 7	Arg. 10	Arg. 11
Top Crop	S	S	S	S	S
Double White	R	R	S	S	S
Perry Marrow	R	R	R	S	S
Calima	R	R	R	S	S
BAT 841	R	R	R	R	R
AB 136	R	R	R	R	R

Table 15. Germplasm accessions showing an intermediate level of resistance to web blight under field conditions at the Turipana station, Monteria, for the A season and in CENICAFE in Armenia, Quindio and Turipana for the B season.

A season	B Season
G 3886[a]	G 2747
G 3887[a]	G 3667
G 3888	G 3699
G 3889	G 4122
G 7120	G 4775
G 7169	G 8142
G 7844	G 8590
G 7895	
G 8252	
G 14513	

[a] Intermediate resistance equal to the Talamanca check variety.

Table 16. Germplasm bank accessions and hybrid lines showing intermediate and resistant reactions to moderate web blight infection under field conditions at CENICAFE, in Armenia, Quindio.

G 4884	PVA 1195[a]
G 5701[a]	PVA 800 B
G 7099	PVA 988[a]
G 7796	PVA 1380[a]
G 9594	PVA 1019
G 10477	PVA 1029
G 10539	PVA 800 A
G 10813	PVA 1059
G 10816	A 179
G 12733	A 465[a]
G 7791	

[a] Demonstrated a level of resistance superior to the Talamanca check in at least one of the two seasons evaluated.

Table 17. The most resistant entries to the web blight pathogen *Thanatephorus cucumeris* from the 1984 International Web Blight Nursery (VIM) tested in two locations, and rated for percentage leaf area affected.

Entries	Mean disease severity (%)	
	Turipana, Cordoba	Paraguaicito, Quindio
A 156	17[a]	4
A 237	16	9
A 336	13	4
A 339	12	2
A 364	18	2
BAT 76	17	8
BAT 789	20	9
BAT 1449	13	2
BAT 1510	13	3
BAT 1516	10	3
BAT 1636	16	10
ICTA 81-26	14	9
MUS 6	16	1
MUS 10	19	9
Negro Huasteco 81	25	15
PAI 113	20	9
PAI 114	15	9
XAN 108	19	13
XAN 112	10	10
BAT 1297[b]	22	13
Talamanca[b]	12	7
Calima[c]	40	30
BAT 1155[c]	40	25

a. Average of three replications
b. Resistant checks
c. Susceptible checks

Table 18. Reaction of six bean cultivars to known and new isolates of _Pseudomonas phaseolicola_ showing the apparent occurrence of a new race 3.

Isolate Origin	Tendergreen	Cascade	PI 181954	V 4604	Red Mexican	PI 150414	Isolate
UK (Race 1)	+ (5)[a]	+ (4)	+ (4)	-(1)	- (1)	- (1)	Race 1
USA (Race 2)	+ (4)	+ (5)	+ (5)	+(3)	+ (3)	- (1)	Race 2
Colombia	+ (5)	+ (5)	+ (5)	+(3)	+ (4)	- (2)	Race 2
Mexico	+ (5)	+ (5)	+ (5)	-(2)	+ (3)	+ (3)	Race 2
Tanzania	+ (5)	+ (5)	+ (5)	+(4)	+ (4)	+ (3)	Race 2[b]
Tanzania	- (1)	- (1)	- (1)	+(3)	+ (3)	+ (3)	Race 3
Rwanda	- (1)	- (1)	- (1)	+(3)	+ (3)	- (2)	Race 3
Uganda	- (1)	NT	NT	+(3)	+ (3)	- (2)	Race 3

[a] -, (1) Red-brown necrotic reaction in the area of maximum inoculation either side of the leaf mid-rib (highly resistant).

(2) Red-brown necrotic reaction with a trace of water-soaking (resistant).

+, (3) Some necrosis but more extensive water-soaking largely confined to the area of maximum inoculation (slightly susceptible).

(4) Small water-soaked lesions (mm diameter) distributed at random over the leaf under surface (susceptible).

(5) Larger water-soaked lesions (1-3 mm diameter) distributed at random over the leaf under surface (fully susceptible).

NT, Not tested.

[b] Brown diffusible pigment.

Common bacterial blight (CBB). F_2 and F_3 populations were received from the cross ((Pinto UI 114 x PI 319441) x PI 319443) x Masterpiece, made at the University of California-Riverside for tolerance to drought. After six cycles of screening and recurrent selection for high levels of CBB resistance and seed set and a *P. vulgaris* plant type, lines XAN 159, XAN 160, and XAN 161 were purified and coded. The high resistance observed in the interspecific derived lines is significantly better than that observed in commonly-used sources such as the Great Northerns and PI 207262 (Table 19). Further, the seed shape of the new XAN lines is that of a small kidney (30 gms/100 seeds).

A cross of PI 319443 x G 40111 was made to study the inheritance of CBB resistance from the resistant *P. acutifolius* parent on an entirely *P. acutifolius* background without the confounding effects of interspecific abnormalities. Significant dominance and additive genetic effects were observed, and three genetic factors are believed to control the resistance (Table 20). A broad sense heritability estimate of .83 was calculated using covariances, and the narrow sense heritability was estimated to be .79, calculated using parent-offspring regression.

After purifying XAN 159 and XAN 161 for CBB reaction, crosses to susceptible *P. vulgaris* varieties of similar plant type and maturity were made to study inheritance on a *P. vulgaris* background and determine how many of the resistance genes were transferred to the XAN lines. As early as the second cycle of reselection and purification, JT 72-2, JT 75-2, and JT 76-2, precursors of the XAN Lines, were used as CBB donors in a backcross program using commercial varieties of three CBB-susceptible dry bean classes as the recurrent parents (Table 21). High levels of resistance were readily reselected in the first two cycles of backcrossing.

While additional backcrosses are being made, advanced generations of hybrid progenies from the first crosses and backcrosses are being inoculated and reselected. Results from the first two backcrosses suggest that XAN 159 and XAN 161 combine much better with the determinate, medium-seeded Pompadour Checa than with indeterminate, small-seeded Talamanca and Rojo de Seda.

A second major breeding project in common bacterial blight resistance was conducted for the purpose of recombining intermediate levels of resistance into black-seeded cultivars having commercial grain type, high yield potential, and resistance to BGMV. Earlier BGMV lines were susceptible to CBB, and earlier black-seeded blight-resistant lines experienced difficulties with unstable grain color, and inadequate yield potential and stability.

A crossing and backcrossing program utilizing nine recurrent parents and five XAN donors of diverse genetic background was initiated and carried to the F_2BC_2 generation. One early maturing donor (XAN 112) and one early-maturing recurrent parent (BAT 304) were included in the crossing plan for the purpose of selecting progenies with a full range of maturities. A few cross combinations were made reciprocally for the purpose of assessing possible maternal effects. The principle objective of the project, to select progenies with intermediate levels of resistance to CBB, good grain type, high yield potential, and segregating for earliness and resistance to BGMV, has advanced very well through the initial cross and the first backcross. 16 F_5 lines have already been advanced to the 1984 VA nursery, and an additional 200 single cross and BC1 families are in F_5 and F_4 evaluations as candidates for the 1985 VA, pending results of screening for BGMV in Guatemala. Common blight reactions for populations, selected F_2 plants, and F_3 progeny families are shown in Table 22 for several cross combinations.

The second objective of the study was to obtain estimates of heritability and gain under selection for intraspecific resistance to CBB in a multiple factor breeding program. Six crosses with different combinations of donors and recurrent parents were studied in detail. Following F_2 rating on a plant by plant basis, a sample of five families per cross x disease class combination were advanced to the F_3 progeny test so that heritability estimates were not biased toward either extreme of the disease rating scale. Data were transformed to a percentage of area damaged scale to facilitate statistical treatment. Heritability estimates varied according to the cross (Table 23), but are within the range of easily applied reselection methods. The very low broad-sense estimate for the cross of DOR 44 x XAN 87 appears to have been distorted by very large variability for CBB reaction within the parental stock of DOR 44, and to a lesser extent by the sampling procedure. These results, combined with frequency distribution of F_2 and F_3 for the six crosses evaluated in detail, suggest that intraspecific resistance to CBB is largely a quantitative trait with additive genetic effects.

The evaluation of 780 accessions from the germplasm bank was completed in two seasons' evaluations in 1984. Evaluations of reaction to the razor blade inoculation method and the aspersion method were made (Table 24). A total of 23 accessions were selected for retesting and consideration for the international common bacterial blight nursery (VIB) and/or as parents for crosses in the breeding program.

The first international common bacterial blight nursery (VIB) was assembled at CIAT and distributed in 1984. The first available data for this nursery, which contains 116 entries in three replications, are presented in Table 25.

Table 19. Comparative least square means of CBB checks, parental lines of (Pinto UI 114 x PI 319441) x PI 319443) x Masterpiece, and commonly used CBB resistance sources.

Entry	Mean LS Mean	STD Error LS Mean	Prob>|T| Ho:a	Prob>|T| Ho:b	Prob>|T| Ho:c
Checks					
Porrillo Sintetico	4.96	0.28	0.0001*	0.0001*	0.0001*
XAN 112	1.68	0.29	0.0129*	0.1897	0.0786
Parents					
Pinto UI 114	5.00	0.29	0.0001*	0.0001*	0.0001*
PI 319441	5.00	0.29	0.0001*	0.0001*	0.0001*
PI 319443	1.07	0.29	0.2369	0.1355	0.1523
Masterpiece	5.09	0.33	0.0001*	0.0001*	0.0001*
CBBR Sources					
Great Northern Jules	2.53	0.28	0.0001*	0.0001*	0.0001*
XR 235-1-1	2.78	0.28	0.0001*	0.0001*	0.0001*
Cornell 79-3776-1	1.85	0.29	0.0007*	0.0371*	0.0092*
PI 207262	3.35	0.28	0.0001*	0.0001*	0.0001*
XAN 159	1.27	0.29	--	0.4984	0.5833
XAN 160	1.41	0.32	0.4984	--	0.8107
XAN 161	1.36	0.30	0.5833	0.8107	--

a = LS mean XAN 159 = LS mean entry

b = LS mean XAN 160 = LS mean entry

c = LS mean XAN 161 = LS mean entry

Table 20. Generation means analysis for inheritance of resistance to common bacterial blight in the cross of PI 319443 x G 40111.

Generation	Observed $\bar{x}$	Observed σ^2	Expected	X^2	Model
P_1 = PI 319443	1.34	0.14	1.41	0.82	Ew[a]
P_2 = G 40111	5.00	0.02	5.01	0.10	Ew
F_1	2.16	0.12	2.22	0.45	Ew
F_2	2.79	1.16	2.71	0.80	1/2 D + 1/4 H + Ew
F_1BCP_1	1.81	0.36	1.81	0.0	1/4 D + 1/4 H - 1/2 F + Ew
F_1BCP_2	4.00	1.36	3.61	1.35	1/4 D + 1/4 H + 1/2 F + Ew
				3.52	

[a] $Ew = 1/4\ (V_{P1} + V_{P2} + 2\ V_{F1}) = 0.095$

$D = 4\ F_2 - 2\ (V_{F1BCP1} + V_{F1BCP2}) = 1.20$

$H = 4\ (V_{F1BCP1} + V_{F1BCP2} - V_{F2} - Ew) = 1.86$

$F = V_{F1BCP2} - V_{F1BCP1} = 1.0$

Estimated number of genetic factors k = D = 2.7

$Cov_{F2,F3} = 1/2\ D + 1/8\ H = 0.83$ (expected); 0.88 (observed)

Table 21. Descriptive parameters for check varieties, parents, F_1, and F_2 populations, from backcrossing and reselecting for resistance to *X. campestris* p.v. *phaseoli* in three varieties of *P. vulgaris*.

Generation	Rojo de Seda			Talamanca			Pompadour Checa		
	X	sd	fmdr[a]	X	sd	fmdr[a]	X	sd	fmdr[a]
Porrillo	4.56	0.40	--	4.56	0.40	--	4.56	0.40	--
XAN 112	1.88	0.28	--	1.88	0.28	--	1.88	0.28	--
Rojo Seda	4.75	0.30	--						
Talamanca				4.47	0.42	00			
Pomp Checa							4.22	0.61	--
JT 75-2	1.5	0.0	--						
JT 72-2				1.0	0.0	--			
JT 76-2							1.0	0.0	--
F_1 SxR									
F_2 SxR	2.86	1.18	9%	3.18	1.27	11%	2.69	1.32	25%
F_1 BC_1	3.0	0.0	--	2.0	0.0	--	2.0	0.0	--
F_2 $BC_1 2$	2.58	1.16	8%	1.27	0.41	64%	2.41	1.63	55%
F_2 $BC_1 3$	2.98	1.52	10%	1.8	0.59	20%	2.56	1.40	33%
F_1 BC_{2a}	2.0	0.0	--	1.0	0.0	--	1.0	0.0	--
F_1 BC_{2b}	1.0	0.0	--	1.0	0.0	--	1.0	0.0	--
F_1 BC_{2c}							1.0	0.0	--
F_1 BC_{2a}	2.91	0.94	4%	2.63	1.04	12%	1.29	0.85	88%
F_2 BC_{2b}	3.17	1.47	13%	2.76	1.03	4%	2.67	1.64	39%
F_2 BC_{2c}							2.75	1.44	38%

[a] Frequency of minimum disease reaction. All mdr were 1.0 except that of F_2BC_{2b}, of Rojo de Seda where mdr = 1.5.

Table 22. Common bacterial blight reaction of F_2 populations, F_2 plants selected as BC males; and F_3 family means from selected F_2 plants, vs. resistant and susceptible check varieties, for single crosses and F_2BC_1.

	Initial crosses						First backcross			
	Unselected		Selected				Unselected		Selected	
Identification	No.	$\bar{X}$[a]	No.	$F_2\bar{X}$[a]	$F_3\bar{\bar{X}}$[a]	Asp[b]	No.	$\bar{X}$[a]	No.	$F_2\bar{\bar{X}}$[a]
XAN 112 x DOR 60	671	3.4	12	2.3	1.8	3.2	2674	2.3	8	2.4
XAN 112 x DOR 44	573	3.6	11	2.5	1.7	2.8	722	2.3	3	2.2
XAN 112 x Ica Pijao	564	3.7	6	2.6	1.8	3.0	86	2.3	11	2.2
BAT 304 x XAN 112	706	3.7	13	2.7	1.5	3.5	1558	2.8	9	2.6
ICA Pijao x XAN 87	501	3.9	10	3.1	2.4	3.3	846	2.8	4	2.5
BAT 304 x XAN 87	236	3.8	9	2.9	2.1	3.5	638	2.7	8	2.5
DOR 41 x XAN 91	470	3.8	10	2.6	2.3	3.4	1035	2.8	2	2.5
BAT 304 x XAN 40	544	4.1	9	3.4	2.9	3.3	332	3.1	7	2.6
BAT 304 (susc. check)		4.8			3.9	5.0		4.6		
XAN 112 (rest. check)		2.1			1.5	2.5		2.3		

[a] Mean reaction after inoculation by razor blades, where 1.0= immune and 5.0 = highly susceptible.

[b] Mean reaction after inoculation by razor blades and by water soaking, where 1.0= immune and 5.0= highly susceptible.

Table 23. Genetic parameters calculated for the heritability of common bacterial blight resistance in six R x S crosses of dry beans.[a]

Parents and F_2	X	Reaction CBB $\frac{P1+P2}{2}$	0^2	Heritability[b] Broad	Narrow	Genetic gain Expected	Obtained
DOR 41	36.8		134		.90		
F_2	23.3	22.6[a]	70	.77	.60	11.5	14.5
XAN 91	7.3		2				
DOR 60	41.1		88		.52		
F_2	20.3	23.9	106	.89	.35	5.5	10.5
XAN 112	6.9		3				
BAT 58	27.1		85		.52		
F_2	22.2	16.9	113	.86	.35	7.4	8.6
XAN 112	6.9		3				
BAT 304	45.5		78		.88		
F_2	21.9	26.2	66	.77	.59	10.3	9.3
XAN 112	6.9		3				
XAN 19	11.1		14		.90		
F_2	24.3	22.1	111	.68	.60	18.3	18.3
ICA PIJAO	33.1		89				
DOR 44	32.2		114		.75		
F_2	16.4	20.1	22	.18	.50	5.4	5.8
XAN 87	7.9		3				

a CBB reaction expressed as percentage damaged tissue.

b Narrow sense heritability calculated directly as F_2F_3 parent offspring regression (above) and using the .67 correlation factor recommended by Smith and Kinman for continuous self-pollinated species (below).

Table 24. Accessions and varieties from the CIAT germplasm bank showing an intermediate resistance reaction to *Xanthomonas campestris* p.v. *phaseoli*, in two planting seasons and with two methods of inoculation.

Identification	Season A		Season B
	Blade[a]	Aspersion[b]	Blade[a]
G 2995	-	10	6
G 3894	6	15	6
G 3920	3	15	5
G 4051	5	10	6
G 4052	3	15	6
G 4054	3	5	6
G 4068	2	5	6
G 4071	-	10	6
G 4075	-	5	6
G 4076	5	15	6
G 4079	5	10	5
G 4081	1	10	6
G 4084	2	10	6
G 4437	-	10	6
G 4438	1	15	6
G 4460	2	5	6
G 4895	6	10	6
G 4942	6	10	6
G 6797	6	15	6
G 6798	6	15	6
G 7050	5	5	6
G 8314	6	15	5
G 8565	6	5	6
XAN 93 (R check)	4	1	-
Jamapa (S check)	8	50	-
XAN 112 (R check)	3	5	3
Porrillo (S check)	9	50	7

a Razor blade inoculation, evaluated on a 1-9 scale where 1 = symptomless and 9 = highly susceptible.

b Aspersion inoculation, evaluated as percent of leaf area affected by the disease.

Table 25. The most resistant entries to Xanthomonas campestris pv. phaseoli from the International bean common bacterial blight Nursery (VIB) tested at CIAT, Palmira.

Entries	Method of inoculation: Blade — Disease rating[a]	Method of inoculation: Aspersion — Disease severity (%)[b]
A 193	3	8
BAT 1272	3	6
BAT 1345	5	7
BAT 1582	4	5
Cornell 79-3776-1	2	10
G 6615 (Constanza 1)	3	8
G 13922 (ICA L 24)	3	8
G 40016 (PI 311897)[c]	2	9
G 40020 (PI 319443)[c]	3	13
G 40034 (Nayarit 13B)[c]	2	6
MITA 235-1-1-1-M	5	9
PAD 3	3	5
PAD 22	4	6
XAN 30	2	11
XAN 87	3	11
XAN 137	3	6
XAN 156	4	8
XAN 159 (interspecific)[d]	2	5
XAN 160 (interspecific)[d]	2	5
XAN 161 (interspecific)[d]	2	5
XAN 164	4	11
XAN 170	4	7
XAN 112[e]	3	5
Jamapa[d]	9	35
Porrillo Sintetico[f]	9	40

a CBB reaction on a 1-9 scale where 1 = free of symptoms and 9 = severely affected, average of four readings and two planting dates.

b Average reading from two semesters, expressed as percentage leaf area affected.

c P. acutifolius

d P. vulgaris x P. acutifolius

e Resistant check

f Susceptible checks

c. Resistance to viral diseases

The main activities of Bean Virology for 1984 were : (1) screening for bean common mosaic (BCMV) dominant resistance; (2) screening for common mosaic multiple gene resistance; (3) screening for common mosaic recessive gene immunity; and (4) the management and prognosis of other important viral diseases of beans.

Bean Common Mosaic Virus (BCMV)

Screening for common mosaic dominant gene resistance.

Selection of lines homozygous for the dominant I gene. In accordance with the main character improvement objective of the program, the incorporation of common mosaic (dominant) resistance in improved bean germplasm, the selection of homozygous BCMV-resistant lines involved 86.7% of the total number of breeding materials (21,711) screened this year. Approximately 65% of these materials belonged to the Bean Breeding I (BB I) project for Chile, Peru, Central America and the Caribbean; 21% to BB II for Argentina, Brazil, Mexico and special projects; 3.5% to BB III, mostly for Africa; and 10.5% to agronomy, mainly to confirm resistance in the Bean Program VEF and EP nurseries. Additionally, 138 elite lines and selected parental materials were screened for the Peruvian and Argentinian bean programs, in an effort to complement regional breeding programs which can hybridize and/or select their own materials but lack the necessary facilities and/or materials to screen for viral diseases.

Selection of homozygous BCMV-resistant genotypes exhibiting linkage problems. Last year's report discussed the successful selection of homozygous red-seeded lines, previously shown to manifest linkage problems (desired seed color/BCMV susceptibility). All of the lines developed have commercial seed types and are being tested this year in regional trials in Colombia (the Calima type lines MCD 251254 and the Sangretoro line MCD-241); in Central America (MCD-201, 221 and 241); and in the Caribbean (MCD-231, a Pompadour type).

Two of the main commercial seed types which show similar genetic linkage problems are the yellow-seeded Peruvian Canario or the Mexican Azufrado; and, in Colombia, the cream, red-mottled Cargamanto seed type Out of more than 340 individual Canario plants selected from among the 16 best lines crossed by the Peruvian national program and CIAT with bean common mosaic resistant dominant-I-gene materials, only one plant possessed dominant resistance. This clearly demonstrates the low frequency of recombination of this dominant gene and the yellow 'Canario' seed color. This one plant selection is being multiplied hopefully to purify it for resistance to bean common mosaic.

A similar test was conducted with the best nine Azufrado lines selected by the Mexican national program (in Mochis). In this case, however, all of the test plants proved susceptible to mosaic. A crossing project was subsequently started to assess the feasibility of improving this seed-type and the Canario type through crosses with genotypes carrying stable recessive (bc-3) resistance.

After four cycles of individual selection in segregating (dominant/recessive resistance) lines with the Cargamanto seed type, only darker red-mottled lines have been identified with homozygous resistance to bean common mosaic. The true red types invariably continue to segregate mosaic-susceptible and mosaic-resistant individuals. This genetic linkage phenomenon was confirmed once more during an evaluation of the progeny generated from the cross Calima x Royal Red, to study this problem. Again, only dark-red variants of the Calima seed type could be selected, in the F_1 to the F_5 generation, as homozygous for the dominant I gene. A breeding project was started to incorporate the recessive bc-3 gene into Calima types, not only for Colombia but also for Africa, using a red-seeded variety which most likely carries this stable recessive gene against both mosaic and black root induced by BCMV.

<u>Screening for common mosaic multiple gene resistance</u>

The development of a suitable screening methodology to evaluate germplasm for the dominant I and recessive genes (bc-u and $bc-2^2$), combined in a given genotype to obtain simultaneous resistance to mosaic- and necrosis-inducing strains of BCMV, was the main research effort this year.

The main topics investigated were: (1) the scarcity of black root resistance sources; (2) the relatively limited knowledge available on the possible combination of dominant and recessive genes; (3) the frequency of black root-resistant genotypes in these crosses; and (4) the response of the plant possessing different combinations of the dominant and recessive genes.

For this study, two varieties possessing the dominant I gene (Widusa and Royal Red) were crossed with Red Mexican U.I.35, a source of black root-protecting recessive genes (bc-u, $bc-2^2$). Also, the purification was attempted of the black-seeded Chilean variety Orfeo-INIA, found to be homozygous for the dominant I gene but segregating for the bc-u, bc 2^2 genes. In all cases, the presence of local pinpoint lesions was chosen as a genetic marker to identify plants or lines with multiple gene resistance.

Table 26 shows the genotypes of the parental materials selected, and the probable genotypes of the F_1 generation.

Since, according to Drijfhout "systemic necrosis may occur through the presence of the dominant allele $bc-u^+$, in spite of the homozygous condition of a specific resistance gene effective against the strain used", the F_1 plants were not inoculated. The F_2 and subsequent generations were manually inoculated in all cases with a mixture of the BCMV strains NL3 (to eliminate materials with the dominant I gene only) and NL4 (to eliminate the recessive genes bc-u, $bc\text{-}1^2$, and $bc\text{-}2^2$, in the absence of the dominant I gene).

The results of the evaluation of the F_2 plants from the cross Royal Red x Red Mexican 35, are shown in Table 27, and their corresponding hypothetical genotypes, in Table 28.

The results obtained for the cross Royal Red x Red Mexican 35 suggest that, besides the dominant I gene and the non-specific gene bc-u, both the $bc\text{-}1^2$ and $bc\text{-}2^2$, are required in homozygous form to condition the development of local pinpoint lesions (multiple BCMV resistance). However, when the F_2 population of the cross Widusa x Red Mexican 35 was tested (Table 29), no local lesion plants were observed. The 49 symptomless F_2 plants were grown to maturity, and the 312 plants produced in the F_3 generation were tested again with the BCMV-NL3 + NL4 mixture. The results, shown in Table 30, demonstrated that most of the symptomless F_2 plants were potential local lesion genotypes. It is speculated that the expression of local lesions could be dependant on undetermined environmental conditions and only the gene $bc\text{-}2z^2$, together with the dominant I and the non-specific bc-u genes, is necessary for the expression of multiple BCMV resistance as proposed by Drijfhout (1978). The symptomless plants of the cross Royal Red x Red Mexican 35 are being tested to confirm this hypothesis.

The important conclusion, however, is that the recombination of dominant and recessive genes, to produce stable BCMV resistant lines, seems a feasible objective. Furthermore, the frequency of multiple BCMV resistant genotypes, despite being 1/15 the frequency of dominant I gene genotypes, is still adequate to maintain some genetic diversity in the selected resistant germplasm. For example, the cross Royal Red x Red Mexican 35 produced 15 F_3 families with multiple BCMV resistance. Also, the cross Widusa x Red Mexican 35 generated 302 F_3 individual selections.

The feasibility of combining the dominant I gene with black root-protecting recessive genes, was also demonstrated during the genetic purification of Orfeo-INIA. Of 50 test plants selected at random and inoculated with BCMV NL3 + NL4, 13 (26%) showed black root; 30 (60%) showed local lesions and local defense reaction suggesting the presence of unnecessary recessive genes; and seven plants (14%) showed only pinpoint local lesions. The latter were selected and increased for further testing. All these seven selections have already proved uniform for their multiple BCMV resistance. These plants produced 52 individual and seven bulk selections, the best of which were sent to Chile for field evaluation, to possibly replace the original Orfeo-INIA heterogeneous variety.

Screening for recessive common mosaic immunity

All of the 14,823 CIAT germplasm bank accessions which have passed the quarantine stage, were evaluated this year for the presence of useful recessive, or dominant combined with recessive genes, which are resistant to mosaic and black root. Following a selective screening of the accessions with specific BCMV strains, only seven accessions did not react with either mosaic or systemic necrosis. However, some of these accessions have been observed by electron microscopy to harbor the virus in the inoculated primary leaves. It is possible, that these accessions do not possess the dominant I gene but recessive genes which limit the spread of the virus. This kind of resistance is currently under study to determine its potential singly or coupled with the I gene.

One of these accessions (G 13936), identified in Chile, does not support multiplication of any of the known BCMV strains. This material is already being used in crosses since it is also a highly commercial red-seeded type. This year, the F_3 was evaluated as were subsequent progenies of a cross between G 13936 and A 487 (a line bred for improved plant architecture, which G 13936 lacks) to study the frequency of immune genotypes generated (Table 31). There was good representation of the resistance genes in the F_4 generation, and the true red color and seed size of the G 13936 resistance source could be recovered. This result may circumvent the discussed linkage problems, characteristic of all the red-seeded lines crossed with dominant I gene genotypes. It is possible that G 13936 carries the bc-3 gene, effective by itself against all of the known BCMV strains.

This year, the first lot of materials from breeding III for Africa, were screened for black root resistance. Following three cycles of BCMV selection, 182 individual selections were identified of which 29 were white-seeded types; 23 Azufrados; and 130 red-seeded selections. These materials will undergo a final field evaluation for desirable agronomic traits, prior to a final BCMV confirmation test.

Management and prognosis of other important viral diseases of beans.

Bean Yellow mosaic virus (BYMV). Bean yellow mosaic has now been recognized as a serious production constraint in important bean production countries such as Chile and Turkey. For Chile, the Bean Program in collaboration with INIA, had been incorporating multiple (common mosaic and yellow mosaic) resistance into all the germplasm improved collaboratively. Among the most widely deployed sources of multiple common/yellow mosaic resistance for Chile were the IVT lines, the IVT-CIAT hybrids, and some Great Northern lines which were resistant to the prevalent BYMV strains in Chile. This year, however, the virus has expressed its characteristic pathogenic variability (well over 50 strains are known to exist in the world) and sources of resistance such as the Great Northern lines, are being attacked by what appears to be a new predominant strain of the virus in Chile. In a preliminary screening, none of the previously resistant genotypes of *Phaseolus vulgaris* proved resistant to this pathogenic variant. Current studies are focused on the identification of new sources of resistance in *P. vulgaris* and *P. vulgaris* x *coccineus* hybrids, seeking a more stable level of resistance. One such hybrid, the line IVT 7620, is already being used as a resistant parent. In the case of Turkey, a crossing project has been started with BB II, using the *P. vulgaris* x *P. coccineus* hybrids obtained from IVT (Holland) and the University of

Gembloux (Belgium) to exploit the resistance available in *P. coccineus*, in the absence of adequate information on the BYMV strains which occur there.

Bean southern mosaic virus (BSMV). A serological (ELISA) field survey of bean southern mosaic virus in CIAT bean fields, revealed an average BSMV incidence of 30% in both plants and trapped chrysomelid vectors (*Cerotoma* sp. and *Diabrotica* sp.). Considering this significant virus incidence, the effect of the virus on the main production components of the variety Diacol Calima was determined. The test was conducted under screenhouse conditions, and the plants were grown individually in six-inch pots. Three different sowing dates were selected to evaluate 120 plants per date. Seventy of these Calima type plants were manually inoculated with BSMV and 50 were inoculated with water alone as controls for each date. All the plants were inoculated on one primary leaf 10 days after sowing. The pods were harvested on an individual plant basis and the seed was dried to a 14% moisture content. Three yield components : the number of pods; number of seeds; and seed weight per plant, were recorded and their mean values compared using an ANOVA for groups with unequal sample sizes. The percentage of seed transmission of BSMV in Diacol-Calima was also estimated by growing-out (seedling symptom) and ELISA (serological) tests.

Table 32 shows the effect of BSMV on the three yield components evaluated. It clearly shows that the amount of seed produced and the total weight of the seed produced were significantly reduced by 47.5 and 56.3%, respectively (P = 0.01). Although the number of pods produced per plant was higher in some of the BSMV-inoculated plants, an average of 17.4% of the pods produced by the BSMV-infected plants did not produce any seed.
The ELISA and growing-out tests of the 'Calima' seed produced by the BSMV-infected plants, demonstrated a BSMV seed-transmission incidence of 11.1%, in mature seeds. The growth cycle of the BSMV-infected 'Calima' plants was delayed by as much as nine days as compared to the BSMV-free controls. These results point out the importance of this ubiquitous virus which, despite the relatively mild symptoms it induces, may cause significant yield reduction. Similar studies are underway for bean mild mosaic virus, another viral pathogen often overlooked but with a wide distribution in Central America and Colombia.

Bean golden mosaic virus (BGMV). The new black-seeded BGMV-resistant bean varieties of ICTA and INIA are being distributed throughout eastern Guatemala and the gulf coast of Mexico, respectively. But it has thus far been difficult to transfer the BGMV resistance of DOR 41 (ICTA Quetzal) into indeterminant, small red-seeded types, and impossible to transfer the resistance into medium-seeded and determinant Pompadour and sulphur types. Materials from a broad array of other programs, and from diverse geographical origins, have been included in the International Bean Golden Mosaic Virus Nursery (IBGMVN) for the objective of finding better non-black resistance donors. As a result, a number of lines from the Brazilian breeding programs at IAPAR and CNPAF have been evaluated in the IBGMVN and used as parents in the crossing program (Table 33). However, lines like Rosinha G2, TMD 1, and Aete 1/38 have not performed as consistently over years and locations as have the DOR lines from Guatemala. Nor have these other sources haven't combined well with non-black grain types either, and this has necessitated a more extensive search among national program germplasm and the evaluation of more diverse hybrid variability.

From routine screening of the EP nursery in Guatemala highly resistant lines like A 417, and A 480, derived from the Mexican pinto line G 2024 were identified. RAB 145, PAD 29, PAD 30, and PAD 31 have also been selected from evaluating other nurseries. The INIA program has recommended Mochis 440 and Canario 101 as medium-seeded resistance sources, and DOR 303, a highly resistant medium-seeded line, was selected in Guatemala. It is hoped that these materials, plus non-black lines like DOR 257, DOR 306, and DOR 316 will provide a working base from which to improve non-black, medium-sized, and determinant types. The best black lines from the IBGMVN/82-83 proved to be DOR lines 209, 221, 235, 241, 256, 251, and 257. They are currently being tested regionally with promising ICTA lines L-81-31 and L-81-64. Earliness and resistance to CBB are being sought.

The IBGMVN/84 is the first international disease nursery distributed on a country by country basis according to seed color preferences of the recipients. The 229 entries, which were divided among five basic color groups of the endemic BGMV areas and include a set of 27 standard check varieties, have been selectively distributed to countries.

Table 26. Probable genotypes[a] of the bean varieties Royal Red, Widusa, and Red Mexican U. I. 35 and their F_1 progenies.

Progenitor	Parental genotype	F_1 genotype
Royal Red	I bc-1	
X		II^{+} $bc\text{-}u^{+}bc\text{-}u$, $bc\text{-}1$, $bc\text{-}1^{2}$, $bc\text{-}2^{+}bc\text{-}2^{2}$
Red Mexican 35	I^{+} $bc\text{-}u$ $bc\text{-}1^{2}bc\text{-}2^{2}$	
Red Mexican 35	I^{+} $bc\text{-}u$ $bc\text{-}1^{2}bc\text{-}2^{2}$	
X		II^{+} $bc\text{-}u^{+}bc\text{-}u$, $bc\text{-}1^{2+}bc\text{-}1^{2}$, $bc\text{-}2^{2}bc\text{-}2^{2}$
Widusa	I	

[a] Only the pertinent alleles and genes are shown.

Table 27. Reaction of the F_2 plants obtained from the cross Royal Red x Red Mexican 35 to the simultaneous inoculation of the BCMV strains NL3 and NL4.

Reaction	No. of plants Observed	Expected[a]
Mosaic	430	392
Black root	1.080	1.103
Local lesions	15	18
Symptomless[b]	44	55

[a] According to the genetic model shown in Table 28

[b] Free of the virus

Table 28. Hypothetical genotypes in the F_2 generation of the cross Royal Red x Red Mexican 35, and their reaction to the simultaneous inoculation of BCMV strains NL3 and NL4.

Genotype	Reaction	Frequency
I^+I^+ , ____, ____, ____,____	Mosaic	64/256
I ____, bcu^+ ____,bcl ____, $bc2^2$ ____	Systemic necrosis	180/256
I ____, bcu bcu, bcl ____,$bc2^+$ ____		
I ____, bcu^+ ____,bcl ____, $bc2^2$ $bc2^2$		
I ____, bcu^+ ____,bcl^2 ____, $bc2^+$ ____		
I ____, bcu bcu, bcl^2 ____,$bc2^+$ ____		
I ____, bcu^+ ____,bcl^2____, $bc2^2$ $bc2^2$		
I ____, bcu bcu, bcl^2 bcl^2, $bc2^2$ $bc2^2$	Local lesions	3/256
I ____, bcu bcu, bcl bcl^2, $bc2^2$ $bc2^2$	Symptomless	9/256
I ____, bcu bcu, bcl bcl, $bc2^2$ $bc2^2$		

Table 29. Reaction of the F_2 generation of the cross Widusa x Red Mexican 35 following inoculation with BCMV NL3 and NL4.

Reaction	No. of plants	
	Observed	Expected[a]
Mosaic	358	388
Systemic necrosis	1.146	1.091
Local lesions	0	18
Symptomless	49	54

[a] As calculated for the cross Royal Red x Red Mexican 35.

Table 30. Reaction of the F_3 generation of symptomless F_2 plants selected from the cross Widusa x Red Mexican 35, following its inoculation with BCMV strains NL3 and NL4.

Reaction	No. of plants
Mosaic	8
Systemic necrosis	2
Symptomless	0
Local lesions	302

Table 31. Evaluation of progenies and selections from the cross G 13936 X A 487 for bean common mosaic/black root resistance.

Screening Cycle	Reaction of BCMV NL3 + NL4			No. of individual selections	Seed Type
	Mosaic	Black root	Symptomless		
1	18/31[a]	-	13/31	13	Medium/dark red
2	10 lines	-	3 lines	2	Medium light/ dark red
3	-	-	2 lines	12	Medium/light red
4	-	-	12 lines	12	Medium light red

[a] Denominator indicates total number of plants inoculated

Table 32. Effect of bean southern mosaic virus (BSMV) on three yield components of the susceptible bean cvar Diacol-Calima.

Planting date	Yield component: Pods/plant		Seeds/plant		Seed wt/plant	
	Inoculated	Control	Inoculated	Control	Inoculated	Control
1	9.1[a](2.6)[b]	8.0(2.2)	11.2(8.8)	20.1(6.2)	4.9(4.4)	11.0(3.2)
2	6.4 (3.8)[c*]	7.3(1.3)	7.6(8.8)	18.6(3.5)	3.6(4.4)	11.0(2.1)
3	8.5 (2.7)	6.7(2.3)	10.9(9.16)	17.9(6.6)	4.8(4.1)	8.9(3.3)
x	8.0	7.3	9.9	18.9	4.4	10.3

[a] Mean of 70 BSMV-inoculated plants and 50 control plants per planting date.

[b] Standard deviations are shown in parentheses.

[c*] Significantly different at P = 0.05; all other means for inoculated test plants are significantly different at P = 0.01 in relation to their respective controls.

Table 33. Bean golden mosaic virus (BGMV) reaction of selected parents and hybrid selections evaluated in the IBGMVN from 1979-1984 on a scale of 1-9 where 1 = symptomless and 9 = highly susceptible.

Entry	Londrina (Brazil) 1979	Londrina (Brazil) 1981	Mochis (Mexico) 1981	Monjas (Guatemala) 1979	Monjas (Guatemala) 1981	Monjas (Guatemala) 1983	Monjas (Guatemala) 1984
DOR 41	6	7	2	6	7	5	2
DOR 44	7	7	4	7	8	6	3
DOR 60	-	8	5	-	7	3	4
Turrialba 1	6	7	6	7	7	7	4
Porr. Sint.	6	6	6	6	9	5	4
ICA Pijao	7	7	4	7	8	5	3
Rosinha G2	-	-	6	-	-	8	6
TMD 1	-	4	6	-	8	8	8
Aete 1/38	5	4	5	6	7	9	8
CENA 164-1	7	8	-	5	8	-	-
H 771-28-1	-	6	-	-	8	-	4

d. Resistance to invertebrate pests

Evaluations for resistance to Empoasca kraemeri, Apion godmani and seed-infesting bruchids continued during 1984. Also, evaluations of some bean accessions were initiated in 1984 for their reaction to an important introduced pest in Central America and Mexico, the slug Vaginulus plebeius Fisher (Veronicellidae).

Empoasca kraemeri (Ross and Moore). Although E. kraemeri appears to be the principal species of Empoasca attacking beans in the areas of Central America, the Caribbean and Colombia, it cannot be confidently stated that it is the most important species in the rest of Latin America. The reaction of bean accessions could be different for different species of Empoasca. There seem to exist differences for resistance in beans between E. kraemeri and the most important Neartic species E. fabae (Harris). Correlations between damage ratings of beans in the USA by E. fabae and in CIAT-Palmira by E. kraemeri were significant for only one of five groups of data (Table 34). However, since damage ratings are qualitative data that are not normally distributed, this type of comparison might not be valid.

Capture and mortality of early instar nymphs of E. kraemeri by hooked trichomes on bean accessions has not been nearly as successful as was reported against E. fabae (Table 35) (Pillemer and Tingey 1978).

In 1984, some red and white-seeded selections from crosses for resistance to the leafhopper reached yield levels near the best black lines under E. kraemeri attack (Table 36). White and red seeded lines have usually been poor yielders under leafhopper pressure. Mulatinho lines (cream-colored seeds from a purple-flowered plant) have shown the highest level of resistance to E. kraemeri. Some of the mulatinho EMP lines are not pure cream-colored but contain a large proportion of unacceptable gray or purple-colored seed. The best mulatinho lines are being purified for seed color. Pure cream-colored selections of EMP 81 yielded better than the original EMP 81 (Bean Program Annual Report 1983).

Increased emphasis has been placed on sending materials resistant to E. kraemeri to countries in as early generations as is feasible. Evaluation of germplasm bank entries has continued, and the accessions currently available in the germplasm bank have all been evaluated for their reaction to E. kraemeri. Attention has been given to finding additional sources of resistance other than tolerance, to raise overall levels of resistance.

The accession of P. acutifolius that was used as a source of resistance to common bacterial blight (CBB) for interspecific crossing to P. vulgaris was moderately resistant to E. kraemeri (Table 37). Results of three field trials do not show significant transfer of this resistance to lines selected for resistance to CBB (results of the final study are given in Table 38). However, these results could be expected since early generation selections were not made with resistance to E. kraemeri as an objective.

Pubescence may be considered the most universal form of resistance to *Empoasca* spp. Pubescence has been noted to reduce population levels of different species of leafhoppers in such diverse crops as soybeans, cotton, lima beans and alfalfa. Although P. *vulgaris* is generally a glabrous plant species, pubescent accessions exist, such as G 00889, G 15818, G 15423 and G 15427. Field counts of leafhopper nymphs on such accessions have often shown reduced population levels on pubescent accessions, although controlled screenhouse studies have not found significant differences. Part of the difficulty in the screenhouse is that pubescence may be reduced, and in young plants a large proportion of oviposition may occur on primary leaves or the first trifoliate, which are glabrous. Plants seem to become more pubescent as they age. Further studies are being conducted to determine whether pubescence will be a useful character in beans for resistance to *E. kraemeri*.

Up to the 6th and 7th cycles of recurrent selection most progress in breeding for resistance to *E. kraemeri* has been made in the cream colored (mulatinho, group 50), and in the small red (group 20) and white (group 30) colored groups, all of Type II and III plant growth habit (Table 36). Less progress has been achieved in the small opaque black seeded types (group 10), since the best black EMP lines (84, 82, 44) are not significantly better than elite black lines such as ICA-Pijao, BAT 448, BAT 271, BAT 76 and Turrialba 1. Black-seeded lines as a group generally had good resistance to E. *kraemeri* before the breeding effort was initiated.

Increased attention is being given to Type I plants and lines with larger seed sizes (groups 25,35), which contain little resistance. Pubescence occurs in some Type I plants a with large seed size, such as Linea 24. These are more resistant to *E. kraemeri*, than glabrous Type I's. Results of an F_2 yield test of Type I materials is given in Table 38. The best of these populations will be intermated in the recurrent selection scheme.

Apion godmani. Breeding for resistance to *A. godmani* is conducted in close collaboration between national bean programs in Central America and CIAT. The highest levels of resistance to *A. godmani* are found in late maturing, poorly-adapted accessions, such as L-17. APN lines have been developed which are better adapted and show high levels of resistance, examples are given in Table 39.

A high degree of correlation between the proportion of damaged pods (x) and damaged seeds (y) for *A. godmani* has been found : $y = 0.27x + 0.23x^2$; $r^2 = 0.88$. This relationship did not vary significantly for different bean accessions, countries or years. Therefore, in 1984, only pods were counted as damaged or not; seeds were not counted. This saved considerable time in the evaluation. A sequential sampling plan has been devised using the following equation given by Kuno (1969) :

$$T_n = \frac{1}{D^2 + \frac{1}{n}}$$

where:

T_n is the number of pods of n sampled that must be damaged by A. godmani to terminate sampling.

D is an index of precision equal to the standard error for a sample mean divided by the mean.

Table 40 is an example of an abbreviated sampling table devised by this method for D = 20%. Sequential sampling should further save time and, more importantly, optimize sampling efforts as more time would be spent evaluating the more resistant materials, while the susceptible ones would be discarded rapidly. This scheme could also help optimize evaluations of nurseries for other projects.

Seed-infesting bruchids. F_3 selections from additional crosses between commercial bean types and wild P. vulgaris sources of resistance to Acanthoscelides obtectus and Zabrotes subfasciatus resulted in more promising materials for resistance to these two dry seed-infesting insects (Table 41).

In some areas of the world, such as the highlands of East Africa and Latin America and the temperate region of South America, the most important species attacking dry beans is A. obtectus. More sources of resistance exist to A. obtectus than to Z. subfasciatus, and some of these sources possess a larger seed size (12-22g/100 seeds) than those resistant to Z. subfasciatus (4-8g/100 seeds). Crosses have been made using sources with larger seeds and resistant only to A. obtectus, such as G 12895 and G 12946.

The slug, Vaginulus plebeius. Vaginulus plebeius Fisher (Veronicellidae) is an introduced slug to Central America. Presently, it is of economic importance in El Salvador, where it was first reported, eastern Honduras, eastern Nicaragua and the northern part of Costa Rica and it continues to extend its area. It may also be the slug that is of primary importance in the Mexican state of Veracruz. Farmers in some areas have stopped growing beans during the August planting season due to slug attack. It is most severe during this season because soils are not as well prepared before planting as they are in May.

During a seminar on slug control held at the Panamerican Agricultural School in Honduras in April 1984, proposals were discussed for research aimed at controlling the pest. CIAT committed some resources to the evaluation of germplasm for resistance to V. plebeius (the slug exists at Palmira) and the search for natural enemies of the slug.

In one test performed with whole plants infested with two slugs/plant for 24 hrs in the glasshouse, significant differences were found in consumption of bean foliage among accessions of P. vulgaris and other plant species. Cowpea was least consumed, followed by some P. acutifolius accessions. In general, there was good correlation between consumption measured in weight or area; the exception was G 10,000 which possessed relatively thinner leaves than the other accessions.

Significant differences were found in leaf area consumed of cultivars grown in the field and tested under no-choice conditions in petri dishes in the glasshouse (Table 42). The varieties Wade and Tara remained among the least consumed cultivars, although defoliation was still considerable. Likewise, Jamapa, the principal cultivar in the areas of Veracruz where slugs are important, continued to be among the most consumed. Similar results were noted for plants grown in the glasshouse.

Whole plants infested with slugs in cages in the field showed great variation in defoliation. In the field, it was noted that primary leaves were generally more frequently attacked than trifoliates but this was not confirmed in petri dishes in the glasshouse (Table 42). Perhaps due to the physical position of primary leaves on the plants they are simply encountered first by the slugs.

The differences observed between cultivars of P. vulgaris for slug defoliation were small and may not stand up to intense slug pressure in the field. Seeds of the less preferred cultivars have been sent to cooperators in Veracruz and Honduras for field evaluation. If similar reactions are be found in Central America, evaluations of materials for resistance at Palmira will continue.

Table 34. Correlation between Empoasca kraemeri damage to bean accessions at CIAT-Palmira and E. fabae damage to the same accessions in the USA.

Source of USA data	Probability	Correlation coefficient
International Bean Rust Nursery at Beltsville, MD, 1976[a].	0.0001	0.41
E. kraemeri resistance nursery at Beltsville, MD, 1976[a].	0.42	0.10
Chalfant (1965) at Fletcher, NC.	0.07	0.53
Wolfenbarger and Sleesman (1961) at Wooster, OH.	0.58	0.14
Ibid. at Marietta, OH.	0.86	0.04

[a] USA data from J. P. Meiners, Beltsville Agr. Res. Center, USDA, ARS, Beltsville, MD, and J. M. Shalk, U. S. Vegetable Breeding Lab., Charleston, SC.

Table 35. Percentage of early instar nymphs of _Empoasca kraemeri_ captured by hooked trichomes of bean accessions in the screenhouse after 24 hours.

Accession	% nymphs captured		
	Trial 1	Trial 2	No hooked trichomes/cm^2
California Light Red Kidney	8.1 a*	11.1 a	3450
Brasil 343	5.9 a	2.1 b	400
G 14233	-	14.3 a	2500

Pillemer and Tingey (1978) reported nymphal mortality after 24 hours ranging from 27-37% on California Light Red Kidney.

* Figures in the same column followed by the same letter are not significantly different at the P=0.05 of the Duncan Multiple Range Test.

Table 36. Reaction of the best lines from the latest selections for resistance of beans to *Empoasca kraemeri*.

Entry	Seed color[a]	Yield kg/ha Infested by leafhopper	Yield kg/ha Protected with insecticide	Damage Scale[c]
EMP 135	mulatinho	1789	2438	5
ER 8236-2-CM	carioca	1626	2273	5
ER 8123-9-CM	red	1543	2005	5
ER 8144-3-CM	mulatinho	1565	1972	5
EMP 84	black	1443	2087	6
ER 8183-10-CM	red	1446	1995	5
EMP 86	mulatinho	1341	2027	4
ER 8227-6-CM	white	1433	1914	4
ICA Pijao	black	1404	1848	5
ER 8108-4-CM	red	1139	1872	6
ER 8138-9-CM	black	1245	1850	5
IPA 74-19	mulatinho	1177	1769	5
ER 8227-5-CM	white	954	1772	5
ER 8153-1-CM	white	1148	1559	5
Ex Rico 23	white	807	1447	6

[a] Mulatinho; cream-colored from a purple-flowered plant; Carioca; cream with stripes.

[b] 1= no damage, 9= heaviest damage; mean of rating at 30 and 40 days after planting.

Table 37. Reaction of parents and best progenies of a P. vulgaris x P. acutifolius cross to Empoasca kraemeri.

Material	No. nymphs/ 10 trifoliates[a]	Damage scale[b]
G 40020 (acutifolius)	9.5 a*	2
G 10022 (vulgaris)	9.7 a	6
G 04509 (vulgaris)	18.7 b	6
EMP 81[c]	15.2 ab	4
XAN 159	19.2 b	6
XAN 160	21.2 b	6
XAN 161	12.5 ab	6
JT76-2-1-M	17.0 ab	5
JT78-4-1-M	13.0 ab	6

a G 40020 and especially G 10022 have smaller leaves than the others. When corrected for leaf area, there are no significant differences.

b 1= no damage, 9 = dead plant.

c Resistant check.

* Means followed by the same letter(s) are not significantly different at 5% level, Duncan. Multiple range test.

Table 38. Reaction of F_2 populations from an interspecific cross between *Phaseolus acutifolius* and *P. vulgaris* of Type I plants to infestation with *Empoasca kraemeri*.

Population or line	Cross	Seed size	Yield (kg/ha)	Damage scale[a]
ER 11350	BAT 1366 x BAT 1727	Large	983	5
ER 11345	BAT 1366 x BAT 1327	Large	684	6
ER 11349	BAT 1366 x A 464	Large	677	6
ER 11330	ER 8132-13-5-CM x BAT 1366	Large	669	5
ER 11327	ER 8132-13-5-CM x BAT 1327	Large	609	5
ER 11348	BAT 1366 x BAT 1558	Large	593	5
ER 11346	BAT 1366 x BAT 1413	Medium	526	6
ER 11335	ER9218-16-2-CM x A 464	Medium	521	6
A 132	-	Medium	499	5
ER 11336	ER 9218-16-2-CM x BAT 1366	Large	492	6
BAT 1366	-	Large	482	6
ER 11328	ER 8132-13-5-CM x BAT 1429	Large	480	6
ER 8132-13-5-CM	-	Large	468	6
ER 11347	BAT 1366 x BAT 1429	Large	427	6
ER 11332	ER 9218-16-2-CM x Línea 24	Small	408	5
ER 11333	ER 9218-16-2-CM x BAT 1429	Large	406	6
BAT 1753	-	Small	322	7
Diacol Calima	-	Large	204	7
Línea 24	-	Large	143	6
ICA Palmar	-	Large	76	7

[a] 1= no damage, 9 = dead plant; mean of ratings at 30,40 and 50 days after planting.

Table 39. Resistance levels of some lines and varieties in terms of percentage of pods damaged by *Apion godmani* in Guatemala.

Lines and varieties	% damaged pods
APN 42	12 a*
APN 83	13 a
APN 84	13 a
SAN MARTIN	15 ab
APN 81	16 ab
APN 78	17 ab
APN 68	19 ab
L-17-6	25 ab
ICTA-TAMAZULAPA	31 ab
ICTA-QUETZAL	42 b

* Means followed by the same letter are not significantly different at the 5% level of the Duncan Multiple Range Test.

Table 40. Example of an abbreviated sequential sampling table to estimate the proportion of bean pods damaged by *Apion godmani*, maintaining the level of precision (D) at 20%.

Number of pods sampled (n)	Minimum number of damaged pods necessary to terminate sampling (T_n)	Proportion of damaged pods	Estimated proportion of damaged seeds
5	5	1.00	0.50
6	5	0.83	0.38
7	6	0.86	0.40
8	7	0.88	0.41
9	7	0.78	0.35
10	8	0.80	0.36
15	10	0.67	0.28
20	12	0.60	0.24
30	14	0.47	0.18
50	17	0.34	0.12
100	20	0.20	0.06

Table 41. Reaction of selected F_3 plants from crosses between commercial bean Types and wild Phaseolus vulgaris as sources of resistance to seed-infesting bruchids.

Cross, line, or variety	Wt. 100 seeds (g)	Insects infested[a]	% emergence of adults	days from egg to adult	dry wt. of adult (mg)
BAT 1235 x G 10019	10	Ao.	7	43.4	22
BAT 1274 x G 12952	10	Ao.	10	46.7	13
V 8030 x G 10019	10	Ao.	9	41.3	24
G 12891 x Carioca	12	Ao.	5	45.0	17
Diacol-Calima	36	Ao.	74	35.3	26
Ancash x G 12952	12	Zs.	8	53.0	7
BAT 1276 x G 12952	14	Zs.	27	47.7	8
Diacol Calima	36	Zs.	89	31.3	15

[a] Ao = *Acanthoscelides obtectus*; Zs = *Zabrotes subfasciatus*.

Table 42. Percentage foliar consumption of accessions by the slug *Vaginulus plebeius* of excised leaves of *Phaseolus vulgaris* grown in the field.

Entry No.	Cultivar	Area of foliage consumed by 2 slugs/day (cm^2)	
		Primary leaves	First trifoliate
G 04050	27-R	22.2	18.5
G 06725	Wade	22.2	24.3
G 05478	Tara	17.3	25.7
G 06572	Idaho Refugee	20.3	28.5
G 05358	Negro Mecentral	21.2	28.0
-	EMP 84	25.7	30.5
G 02742	Zamorano	23.8	31.2
G 01876	Zamorano	18.8	35.5
-	Huetar	25.8	35.7
G 06302	Cuarenteño	25.8	36.2
-	BAT 41	26.0	37.8
-	Jamapa	20.0	41.8
G 01459	Jamapa	18.7	44.0

e. Yield Potential

Although previous research at CIAT has demonstrated that yield potential could be increased if late maturing lines are developed, this approach has proven difficult because of lack of variability for lateness. In addition, it is not clear how many production areas could accept later maturing lines in their present cropping systems. Thus, although lateness will continue to be sought as a route to absolute maximum yield, overall work on yield potential is also being directed toward other groups of materials including, medium and large-seeded lines and early maturing lines.

Research is presently guided by several working hypotheses based on previous attempts to improve yield:

(1) Direct selection for increase in yield components will have little effect due to compensation. There is undoubtedly room for optimization of combinations of components, but this will require detailed studies within materials of similar maturities and grain types.

(2) Irrespective of time to maturity, the highest yielding lines will tend to be those which rapidly establish a large leaf area, and maintain leaf area until the end of podfill when remobilization will cause rapid senescence.

(3) An essential component of high yield potential is high adaptation to local conditions. Optimal temperature responses of photosynthesis and maintenance respiration will maximize the assimilate available for growth, while photoperiod response may be essential in determining efficient partitioning.

(4) If the range in variation of characters with strong correlations with yield or basic growth patterns, such as time to maturity, seed size or growth habit, is too great within a trial, the effects of these characteristics will tend to mask effects of other variables. Thus, studies attempting to account for effects of multiple characteristics should be subdivided for appropriate classes of materials.

(5) Determining combinations of characteristics leading to increased yield potential will ultimately depend on having techniques capable of describing interactions of a large number of variables, each having a small effect on yield potential. This will require use of quantitative models.

(6) For information to be of use to breeders, characteristics must be sought which can either be measured through simple field observations or laboratory tests.

As an initial step toward defining a more precise strategy for improving yield potential, the growth of 30 medium to large- seeded and 30 small-seeded lines are being compared in a series of four yield trials. The data will be of greatest value when all trials are completed, but results from the first trial illustrate several points of the strategy.

The first variables presented in Table 43 represent some of the efforts to identify new types of selection criteria. Canopy cover at 20 days (determined with a point quadrat) should reflect a variety´s ability to rapidly establish leaf area. Time to appearance of the first branch leaf should vary with the tendency to develop branches, and may also reflect time to flower if there are developmental correlations between branch growth and flower initiation. The amount of pollen per flower may affect the efficiency of seed set, which although it is not expected to produce dramatic increases in seed yield, but may be important in optimizing yield components. (Because of the labor required in determining the amount pollen/flower, data was only taken for the medium to large-seeded lines.) Similarly, measuring the maximum number of seeds per pod was expected to reveal more about potential seed set than mean number of seeds per pod, and would also be much easier to use as a selection criterion in the field.

The generally low correlations among these and other parameters may seem disappointing (Table 44), but this is actually seen as a step forward, confirming that many variables, each with a relatively small effect, determine yield potential. Since the program expects complex interactions among different growth parameters, strong correlations, due to use of too broad a group of materials, would have smothered the relations of interest to the team. This suggests that the two groups of materials were properly selected as having a sufficiently limited range of maturation and seed sizes.

Table 43. Characteristics of best-yielding medium to large-seeded and small-seeded lines in trials 8403 and 8404, respectively.

Medium to large-seeded lines:	PVA 1070	A 322	BAT 1617	PVA 1189	A 114	Mean	S.E.
Canopy cover (% at 20 days)	45	45	41	48	42	45	4.2
First branch leaf	20	20	21	20	21	21	1.2
Pollen/flower	6400	4000	6600	6300	5500	5100	1600
Max. seed/pod	5.0	6.5	5.8	5.0	6.3	5.7	.67
Growth habit	I	III	I	I	III		
Days to flower	33	33	35	33	37	35	0.6
Days to maturity	72	72	76	74	80	77	1.6
Yield (g/m^2)	188	172	171	166	162	135	16.7
Yield/day ($g/m^2.d$)	2.6	2.4	2.3	2.2	2.0	1.8	.21
Crop dry wt. (g/m^2)	344	275	370	318	305	276	38.9
Harvest index	.62	.65	.57	.59	.59	.54	.028
100 Seed wt. (g)	36	25	31	48	25	32	1.8

Small seeded lines	BAT 1647	BAT 1481	BAT 477	A83	BAT 1554	Mean	S.E.
Canopy cover (% at 20 days)	42	46	50	44	37	44	.6
First branch leaf	23	22	22	22	27	22	5.3
Max. seed/pod	6.5	7.0	7.3	7.0	6.3	6.8	.92
Growth habit	II	II	II	II	II		
Days to flower	37	38	33	37	38	37	.6
Days to maturity	76	74	73	76	76	75	1.0
Yield (g/m^2)	213	209	203	201	195	181	14.3
Yield/day ($g/m^2.d$)	2.8	2.8	2.8	2.6	2.6	2.4	.18
Crop dry wt. (g/m^2)	371	336	339	365	321	312	36.3
Harvest index	.61	.60	.62	.63	.60	.60	.021
100 Seed wt. (g)	16	16	19	22	14	18	.7

Table 44. Correlations among various growth parameters.
For large and medium seeded lines, p = .05 for r = ±.38.
For small seeded lines, p = .05 for r = ±.36.

	Canopy cover	1st br leaf	Pollen grains	Max.seed /pod	Yield
Medium to large seeded lines:					
First branch leaf	.12	--			
Pollen gr./flower	-.19	.37	--		
Max. seed/pod	-.34	-.37	.04	--	
Days to flower	-.28	-.10	.02	.33	-.04
Days to maturity	.03	-.04	-.05	.11	-.02
Yield	.29	.02	-.02	-.22	--
Yield/day	.28	.02	-.04	-.22	.94
Crop dry wt.	.41	.09	.06	-.20	.71
Harvest index	-.19	-.38	-.32	.15	.30
100 seed wt.	.37	.27	.04	-.69	.29
Small seeded lines:					
First branch leaf	.04	--			
Max. seed/pod	.38	.17		--	
Days to flowering	-.64	.09		.00	-.31
Days to maturity	-.18	-.10		.42	-.09
Yield	.24	.45		.21	--
Yield/day	.29	.46		.06	.94
Crop dry wt.	.33	.34		.22	.75
Harvest index	.00	.04		-.05	.17
100 Seed wt.	.21	-.08		.11	-.02

Yield potential and seed size. It has consistently been observed that yields of large-seeded bush beans are lower than those of small seeded ones. Explanations which have been forwarded include:

(1) Large-seeded lines are predominantly early-maturing Type I's.

(2) Large-seeded lines are predominantly cool climate or temperate zone materials, and are simply poorly adapted or lack essential disease resistances.

(3) There is an inherent growth correlation between seed size and possibly undesirable architectural characteristics such as large leaves and long internodes.

(4) The growth of pods of large-seeded lines is accompanied by an unusually high sink demand (necessary to permit growth of large seeds), and thus individual pods trigger source-sink imbalances which reduce the overall efficiency of the whole plant.

In a trial examining the fourth hypothesis, growth of single pods was monitored. Defoliation (approximately 60%) and defloration (removal of developing flowers and pods) were included to test the sensitivity of individual pod growth to the source-sink balance of the plant. Pod growth parameters for six sampling dates (pod length, fresh weight, seed and pod wall dry weights) were recorded.

When the pod growth of the control treatments of the four lines (Figure 5a), were compared. The growth pattern of the large-seeded lines (A 195 and Linea 24) differed from small-seeded ones (BAT 1297 and A 78) principally through duration of podfill, including a longer period of rapid pod filling. This extended period of high individual pod demand for assimilates or nutrients could trigger local source-sink imbalances. A possible solution could be to develop lines with fewer ovules per pod to reduce sink strength. Emphasis is given to ovule number since selecting for fewer seeds per pod would probably result in selection of lines with poor seed set.

Attempting to modify pod growth patterns through defoliation and defloration treatments scarcely affected the growth of individual pods of Linea 24 (Figure 5b). This suggests that for pods at the lower position on the main stem, individual pod growth is insensitive to moderate shifts in the source-sink balance of the bean plant, and thus that such pods are appropriate for basic studies on pod growth.

Screening for variation in maturity. As a broad range of disease resistances becomes available, there is an opportunity to diversify the range in maturities found among CIAT lines. Later maturing lines are expected to result in increased yield potential, and while early lines are of interest for a range of reasons, yield stability is perhaps the most important. A program for development of lines representing greater ranges in maturities has been initiated with the following objectives:

(1) Identify parents of different growth habits and seed characters giving earliness (less than 70 days to maturity at CIAT-Palmira) or lateness (more than 85 days) with high yields.

(2) Develop selection criteria for earliness or lateness with good yield.

(3) Breed high yielding lines combining earliness or lateness with disease resistance and other commercially important characteristics.

In the first stage of this work, early and late maturing lines were evaluated in parallel nurseries of approximately 180 lines each. Considerable variation for earliness was detected, although no extremely early Type II's were found, and the range of seed types was also limited (Table 45). Yield potential will be reduced with increased earliness, but it is encouraging to find a material such as G 3017, capable of yielding over 2 t/ha in 60 days. Later maturing lines appear much more difficult to obtain. Of particular concern is the difficulty in identifying late materials free of problems with flower, pod or seed abortion that result in lateness with low yields. From each nursery, 40 lines are being evaluated for yield and photoperiod response, and will be used as parents in breeding for increased earliness and lateness.

To guide selection of early and late lines, various parameters were analyzed and correlated from data of the two nurseries (Table 46). From these data the following are noteworthy: the node bearing the first inflorescence on the main stem may have utility as an indicator of time of flower initiation. Large seeds are associated with a longer period of podfill.

Table 45. Promising lines from screening for extreme earliness or lateness.

CIAT no.	Habit	100 seed wt. (g)	Node of lrst in-florescence	Days to flower	Days to maturity	Yield (g/m2)	Yield /day
Early lines:							
G 2883	1	27	5.2	26	56	68	1.21
G 4450	1	38	7.0	31	66	220	3.33
G 51	1	31	6.2	30	66	213	3.22
XAN 145	2	14	8.0	35	68	209	3.08
G 2858	3	35	7.2	27	68	190	2.79
G 1965	3	18	6.6	32	65	136	2.09
G 1344	3	16	5.8	32	65	165	2.54
G 2923	3	21	6.6	31	63	200	3.17
G 1345	3	16	6.8	32	64	202	3.15
G 3017	3	19	4.8	27	60	212	3.53
Late lines:							
PAD 13	1	44	8.4	37	81	244	3.01
A 471	1	35	7.2	38	82	220	2.68
PVBZ1902	3	20	9.4	41	81	234	2.89
PVBZ1782	3	22	7.2	40	82	259	3.16
VRB81023	4	24	8.6	37	80	269	3.37

Table 46. Correlations among various characteristics in nurseries for earliness and lateness. Upper right triangle of coefficients is for early lines; p = .05 at r = +.17. Lower left triangle, for late lines; p = .05 at r = +.23.

	Flowering	Onset pod-fill	Maturity	Duration Pod-fill	Node inflo res cence	100 seed wt/w	Seeds/ pod	Max seeds/ pod	Yield
Days to flower		.80	.71	.21	.58	-.43	.52	.43	.06
Days to podfill	.60	---	.58	-.13	.44	-.42	.50	.48	.24
Days to maturity	.37	.34	---	.43	.41	.05	.24	.18	.49
Duration of podfill	-.44	-.10	.55	---	-.12	.66	-.30	-.27	.43
Node of 1rst inflorescence	.39	.32	.35	-.04	---	-.33	.34	.26	.19
100 seed weight	-.55	-.40	.02	.54	-.15	---	-.64	-.62	.22
Seeds/pod	.39	.32	.04	-.32	-.05	-.61	---	.77	.11
Maximum no. seeds/pod	.30	.29	.03	-.31	.00	-.58	.78	---	.19
Yield	-.25	-.33	-.09	.15	-.30	.23	.04	.03	---

Variation in individual plant yield Assuming that variation in individual plant yields reflects levels of interplant competition, and that competition reduces the overall efficiency of the crop, a relatively uniform distribution of yield per plant within a plot might increase yield potential. An understanding of this aspect of competitive ability might also aide in the prediction of performance of mixtures or beans in association with other crops. Furthermore, variation in individual plant yield may be related to yield stability. A line giving highly variable individual yields might be more stable since it has the capacity to compensate for poor parts of a field. Or arguing for the reverse of this relation, a line showing low within-plot variability could be showing tolerance to variable field conditions, and would be more stable.

To explore such relations, data for pods per plant were recorded for 10 lines (40 to 60 plants each in four replicates), pods per plant being an index of plant growth which can be measured rapidly in the field. Three depths of sowing were used in separate plots to augment variation through effects on uniformity of emergence, but since no depth effects were found, the data were analyzed for means of all depths.

To illustrate the variability found, data for pods per plant are presented in Figure 6. The most striking result was that the two best yielding lines, A 83 and BAT 1198, differed greatly in variability as indicated by the standard deviations (SD) of pods per plant (Table 47). Since these lines are both small-seeded Type III's and had similar populations of plants, the lines appear to follow different strategies for producing high yields.

Although the mean (M) and standard deviation of pods/plant were highly correlated, suggesting a Poisson distribution, coefficients of dispersion (CD) estimated for each line (CD = SD/M) showed a systematic deviation from a value of 1, violating a second requirement for a Poisson distribution. Comparing the yield and CD, BAT 1198 and BAT 1671 had large CD's and high yields, while A 83 a had low CD but similar yield.

Table 47. Variation in individual plant growth within plots as measured in terms of pods/plant.

Line	Habit	Days to Maturity	Yield g/m2	Yield/ day	Plants /m2	Seeds /pod	Yield /pod	100 seed wt.	Pods/plant Mean	S.D.	C.D.
A 83	3	77	245	3.20	19.8	5.86	1.56	26.6	10.3	4.5	.76
BAT 1198	3	80	237	2.97	17.4	5.49	0.96	17.5	18.5	10.3	2.01
BAT 1671	3	80	237	2.96	18.8	4.98	1.24	25.0	15.1	8.3	1.66
BAT 1230	2	76	215	2.85	19.5	5.16	1.29	24.9	11.7	5.8	1.08
BAT 477	3	75	212	2.82	17.8	6.72	1.63	24.2	9.5	5.0	1.01
TOCHE 400	3	74	211	2.85	14.8	5.66	1.87	33.0	11.4	6.3	1.32
A 465	2	75	184	2.47	19.3	3.90	1.46	37.5	8.8	4.5	.86
BAT 1532	2	76	183	2.41	17.9	5.74	1.14	19.9	12.2	6.0	1.07
BAT 304	3	74	176	2.38	17.5	5.72	1.34	23.4	9.6	4.3	0.76
A 296	2	75	166	2.20	16.9	5.74	1.23	21.4	12.1	5.9	1.15
Correlation with:											
Yield		.70*	--	.98*	.28	.48	.06	-.07	.47	.48	.46
Pods/plant											
Mean		.83*	.47	.31	-.14	-.04	-.66*	-.58	--	.98*	.94*
S.D.		.80*	.48	.33	-.22	-.07	-.56	-.47	.98*	--*	.99*
C.D.		.75*	.46	.33	-.30	-.07	-.46	-.38	.94*	.99*	--

* P= 0.05.

Pod and seed set. An understanding of the processes underlying pod and seed set will benefit several lines of research. In searching for late maturing lines, many materials with high levels of pod or seed abortion have been found. Under drought or heat stress, flower, pod and seed abortion often increase. Before such problems can be analyzed, techniques are needed for determining pollen fertility, efficiency of pollination, and proportion of ovules fertilized.

Although beans self-pollinate easily, it is not clear how efficient pollination actually is under field conditions, particularly in the absence of insect pollinators which can mechanically trigger selfing mechanisms. To test this, a field trial was conducted including a treatment which consisted of depressing the coiled floral keel, thus causing the stigma to exert and then retreat through the anthers. Presumably, the movement would increase both pod and seed set if self-pollination were increased. Anticipating varietal differences in response, flower buds and open flowers were collected to permit evaluation of quantities of pollen produced, and the success of fertilization (through observation of pollen tubes reaching ovules).

Manipulation increased seed and pod set of some, but not all lines (Table 48), suggesting that they may have varied considerably in their efficiency of pollination. (The few cases where manipulation reduced seed or pod set may reflect overly vigorous manipulation of flowers having damaged some.) Counts of pollen grains per flower did not show a relation as a response to the manipulation technique although there was a nearly three-fold difference in pollen content of different lines. BAT 1670 was noteworthy, having nearly the largest amount of pollen, yet the fewest pollen tubes and low seed set. Note that there is no expectation that increasing seeds per pod or pods per inflorescence will automatically increase yield potential. Unless the capacity of the plant to fill such seeds or pods is also increased, the expected result would be shifts in other yield components (such as a decrease in individual seed weight or in inflorescences per plant), resulting little no change in yield.

Table 48. Response of seed and pod set to floral manipulation in 10 bean lines. Data for pollen and pollen tubes are for control plots only. Cont = control; Man = manipulation treatment.

Line	Habit	100 Seed Wt.	Seeds/Pod		Pods/inflorescence		Seeds/inflorescence		Pollen grains /flower*	Pollen tubes/florescence
			Cont	Man	Cont	Man	Cont	Man		
BAT 1281	3	21	5.0	5.0	.96	.92	4.9	4.8	7700 a	16
A 120	3	32	4.2	4.4	1.30	.75	5.4	3.3	15900 b	14
BAT 202	3	22	2.9	3.8	.14	.37	.4	1.4	16200 bc	16
A 227	3	22	3.1	4.1	.84	.93	2.6	3.8	16900 bcd	17
A 429	2	26	4.5	4.8	.89	1.68	4.0	8.0	17300 bcde	13
A 488	3	27	5.0	5.9	.22	.41	1.1	2.4	17800 bcdef	14
A 463	1	32	2.8	6.4	.32	.55	0.9	3.5	19100 cdef	14
BAT 1061	2	22	5.9	5.8	1.42	1.70	8.4	9.8	19200 def	16
BAT 1670			2.9	2.5	.98	.87	2.9	2.4	20300 ef	7
A 200	3	25	4.9	4.6	1.31	1.22	6.4	5.6	21000 f	20

* Means followed by the same letter(s) are not significantly different (P=0.05) of the Duncan Multiple Range Test.

Yield, yield stability and duration of crop cycle. Low average yields in many regions emphasize that attention should be given not only to maximum yields, but to physiological strategies for low-yield sites. If it is assumed that yields are often low due to factors which fluctuate with time, late maturing lines might have less stable yields than early ones. Stability parameters (mean yield -- Y, regression response on site mean yield -- B, and deviations from regression -- D) were calculated for the IBYAN's from 1979-82. Associations between varietal yields and times to maturity at individual sites were also examined. In high yield sites, yield and maturity should be positively correlated. In low yield sites, yield and maturity might show no correlation, or if early lines were actually better than late materials, a negative correlation would be found.

Correlations between the stability parameters and mean time to maturity (M) across all sites lying within 30^{o} of the equator (to eliminate sites with strong photoperiod effects) were calculated for each IBYAN (Table 49). If the general expectations were to hold, B and D should have had positive correlations with M, while the correlation between Y and M would vary depending on the mean productivity of the IBYAN. For mean yield, no significant positive correlations were found, and in two IBYAN's significant negative correlations were obtained. The other two stability patterns should have accounted for variation in site productivity, but the only IBYAN which showed a positive correlation between maturity and either stability parameter was the IBYAN/76. In comparing data from the 1976 trials to those from the 1978 black-seeded trials (Figure 7) it appeared that one cause of low correlations may have been lack of variability in varietal means (across IBYAN's) for time to maturity, further illustrated by the generally small ranges in maturity indicated in Table 49.

Two extreme cases of associations between yield and maturity are illustrated in Figure 8. Data from individual sites for each IBYAN were used to estimate correlations between varietal yields and times to maturity (Cy.t) Examples of data for Cy.t VS. mean site yields are presented for two IBYAN's in Figure 9. Such data were further summarized by calculating the correlation between Cy.t and mean site yield (Cc.y in Table 49). Significant positive correlations were obtained in 5 of 10 IBYAN's examined, suggesting that late maturity is beneficial in high yield sites, while earliness provides yield stability in low yield conditions.

Table 49. Relations between stability parameters, correlation between length of growth cycle and yield, and mean yields of individual trials. A,B,C and R associated with the IBYAN year indicate seed types as all colors, black, non-black, and cream, respectively. Correlations are : Cy.m = varietal mean yield VS. mean time to maturity. Cb.m = regression response on site mean yield (B) vs. varietal mean for time to maturity. Cd.m = deviations from regression (D) vs. varietal mean from time to maturity. Cc.Y = correlation between yield and maturity for lines at a specific site VS. site mean yields. Days to maturity are for varietal means across IBYAN.

	No. of		Correlation				Days to maturity		
IBYAN	Varieties	Trials	Cy.m	Cb.m	Cd.m	Cc.y	Min.	Max.	Range
'76 A	20	31	.22	.79**	-.06	.51**	72	84	12
'77 B	20	15	-.13	.01	.29	-.13	77	84	7
'78 B	20	19	-.24	-.28	-.14	-.01	82	85	3
'79 B	20	25	-.62**	-.05	.46	.45*	76	84	8
'80 B	13	23	-.43**	.30	.08	.40*	73	80	7
'81 B	12	12	.14	.29	.31	.43	76	84	8
'82 B	12	16	.31	.06	-.40	-.03	77	84	7
'78 C	20	29	.01	.34	-.59**	.36**	77	86	9
'79 C	29	22	-.12	-.05	-.18	-.07	79	87	8
'82 R	20	9	-.12	.46*	.06	.85*	82	94	12

* = p .05. ** = p .01.

f. Tolerance to Drought Stress

Heavy rains in the first semester rendered regular screening useless. In the second season, numbers of materials were reduced to evaluate the present screening strategy and study mechanisms of drought tolerance.

New materials which were evaluated included 14 lines from the Brazilian national program, 100 lines from the EP/84, and three *P. vulgaris* x *acutifolius* hybrid lines showing promising drought tolerances at the University of California at Davis.

The most important effort in evaluating the present screening technique consisted of initiating the Bean International Drought Yield Trial (BIDYT) and the BIDAN (Bean International Drought Adaptation Nursery). The BIDYT is a replicated drought yield trial of 25 lines (with option for irrigated control plots), and is expected to provide data both on performance of materials selected at CIAT-Palmira, and provide collaborators with access to potential parents or lines with drought tolerance. The BIDAN, consisting of 72 lines in unreplicated observation plots, was intended to provide collaborators with a wider range of lines, although sacrificing benefits of replicated yield trials.

Preliminary results of BIDYT's conducted at CIAT-Palmira, Quilichao, and Popayan, and at Chiclayo, Peru (through collaboration at INIPA) confirmed that materials selected at CIAT-Palmira would vary greatly in tolerance to drought at other sites (Table 50). Particularly noteworthy is that the best lines and varieties at Palmira and Quilichao (San Cristobal '83 and G 5059) had 0 yields in Popayan, primarily as a result of poor adaptation.

The large standard errors in the trials reflect the inherent problems of conducting yield trials with naturally induced stresses such as drought, and raise doubts about the utility of unreplicated drought nurseries.

Besides differences between sites an additional concern is that varying water regimes at a site will result in different evaluations of tolerance. Comparing yields of eight lines grown under five irrigation regimes, resulting in yields from 93 to 173 g/m^2, a significant ($p = .025$) line x irrigation regime was found.

Table 50. Drought yields of accessions, lines and varieties (kg/ha) reported from four BIDYT's.

Line	Habit	Seed color	100 seed wt.	Location[a] Palm.	Quil.	Pop.	Chic.	Weighted mean
V 8025	4	black	21	1790	1600	1340	704	1568
BAT 477	3	cream	24	1870	1270	1190	915	1532
BAT 1289	3	red	21	1970	1720	990	742	1456
G 4523	1	red	40	1570	1230	1280	452	1325
A 195	1	cream	52	1650	1240	1090	488	1258
G 4830	2	black	19	1780	1820	690	631	1245
BAT 1393	1	cream	36	1580	1590	710	680	1201
BAT 336	2	cream	21	1890	1540	600	694	1190
G 5201	2	black	18	1510	1500	730	688	1187
BAT 85	2	cream	22	1960	1360	650	605	1154
BAT 1298	3	pink	21	1730	1260	620	585	1075
BAT 868	2	brown	25	1470	1300	460	716	1017
G 4454	2	black	21	1740	1070	680	425	1003
A 97	2	cream	23	1460	1500	370	596	956
A 59	2	brown	27	1710	860	320	648	871
BAT 798	3	black	23	1770	1190	0	812	849
San Crist. 83	3	pink	26	2150	1080	0	705	842
G 5059	2	cream	23	1180	2000	0	502	777
G 4446	3	brown	28	1830	1240	0	544	753
BAT 125	2	cream	23	1550	1340	30	561	751
A 170	2	cream	20	2000	1290	0	444	746
A 54	2	cream	19	1510	1670	0	430	735
EMP 105	2	red	20	1660	1040	0	561	696
Local Check 1				1660	1760	690	783	
Local Check 2				1570	1640	530	505	
Mean				1700	1403	519	617	1060
S.E.				267	316	372	286	

[a] Palm. = CIAT-Palmira
Quil = CIAT-Quilichao
Pop = Popayan, Colombia
Chic = Chiclayo, Peru

Drought tolerance mechanisms. Present selection criteria for drought tolerance, primarily yield and canopy temperature differential, are not efficient enough to permit rapid progress in the search for drought tolerance. Previous studies at CIAT-Palmira have demonstrated that tolerance has been associated with reduced canopy temperature, and that this in turn was associated with less reduction in stomatal conductance and water plant potential during periods of peak stress. These results were attributed to tolerant materials extracting a larger amount of soil moisture --- presumably through deeper roots. To test this hypothesis, root growth of two tolerant and two susceptible lines were measured at CIAT-Palmira. Tolerant lines under stress produced roots reaching over 130 cm deep, while roots of susceptible ones scarcely passed 70 cm (Figure 10). This pattern was associated with differences in soil moisture and plant water status (Table 5), reinforcing the conclusion that deeper roots allowed the tolerant lines to avoid extreme stress.

To test whether this mechanism would break down under shallower soils, the same materials were grown at CIAT-Quilichao, where root growth is usually limited to the first 30 or 40 cm that is affected by the incorporation of $CaCO_3$. Differences in root growth of tolerant and susceptible lines were not found, and yields of tolerant lines under stress were the same as a susceptible one (Figure 11 and Table 51). Thus, it appears that the importance of root growth in determining drought tolerance depends heavily on soil conditions.

These results are insufficient to indicate whether varietal differences in root growth are due to heritable differences in root morphology or to other characteristics, such as overall plant vigor, which indirectly determine root growth. To evaluate the relative importance of root and shoot characteristics, root and shoot systems of tolerant (BAT 477) and susceptible (BAT 1228) lines were interchanged through grafting. Yields of plants with roots of BAT 1228 averaged approximately half of those of the tolerants, and there was no indication of the benefit of the BAT 477 shoot when grafted onto susceptible roots (Table 52).

A similar pattern occurred with plant survival although Macrophomina reduced the stands from an original density of 15 plants/m^2. Unfortunately, the high labor requirement of grafting required very small parcels and use of only three replicates, and significance tests were inconclusive, indicating a need for further studies.

Table 51. Root growth and other characteristics of drought tolerant (BAT 85 and BAT 477) and susceptible (BAT 1224 and A 70) lines at Palmira and Quilichao. D = drought treatment; C = control treatment.

Variable	Treatment	BAT 85	BAT 477	BAT 1224	A 70
Palmira					
Yield	D	1458a*	1457a	548b	570b
	C	2517a	2538ab	2344a	2768b
100 seed wt. (g)	D	16.0	15.9	16.5	22.9
	C	18.6	17.7	19.4	25.1
Seeds/pod	D	4.5	4.6	2.2	2.0
	C	5.7	5.5	5.8	5.7
Pods/m^2	D	221	220	160	125
	C	290	276	264	221
90% root depth (cm)	D	100	100	60	60
	C	50	50	50	50
Root dry wt. (mg)	D	541	599	534	494
	C	660	715	725	598
Specific root length (cm/g)	D	422	345	322	314
	C	204	209	223	310
Canopy temp (°C)	D	34.0	34.3	36.8	37.5
	C	29.2	29.6	29.6	29.9
Leaf water potential (kPa)	D	810	840	1100	1100
	C	450	460	480	470
Quilichao					
Yield	D	589a	724a	723a	192b
	C	2896a	2952ab	2663b	2124c
100 seed wt. (g)	D	23.1	22.4	20.4	24.4
	C	18.2	17.7	17.4	20.9
Seeds/pod	D	4.1	4.4	2.8	1.9
	C	6.1	6.1	5.5	5.3
Pods/m2	D	77	87	157	77
	C	299	292	261	235
90% root depth (cm)	D	30	40	30	30
	C	30	20	20	20
Root dry wt. (mg)	D	924	899	792	668
	C	476	611	688	492
Specific root length (cm/g)	D	188	259	234	216
	C	204	209	223	310
Canopy temp. (°C)	D	38.4	39.8	38.8	41.4
	C	28.6	28.0	28.5	28.5
Leaf water potential (kPa)	D	840	860	950	1030
	C	400	450	450	500

* Yields followed by the same letters within a treatment differ at p = .05.

Table 52. Yield and plant survival of grafted drought tolerant (Tol) (BAT 477) and susceptible (BAT 1224) roots and shoots. Original density at transplant was 15 pl/m^2, however, Macrophomina reduced the stands.

Shoot/root	Yield (g/plant)	Plants/m2
Tol./Sus.	64 a[*]	7.0 ab
Sus./Sus.	54 a	2.3 a
Sus[a]	77 a	7.0 ab
Sus./Tol	139 a	10.7 bc
Tol./Tol.	134 a	8.7 abc
Tol[a]	155 a	14.0 c

[a] Ungrafted controls

* Values followed by the same letter(s) within a column do not differ at p = .05 of the Duncan Multiple Range Test.

g. Photoperiod-Temperature Response

Photoperiod screening has continued at Palmira, using artificial 18 hour daylengths to delay flowering as described in the Bean Program Annual Report 1977. Materials Report, evaluated included lines from various EP's and the germplasm collection and the results from previous screening efforts have been compiled into a list of photoperiod responses of over 3,000 materials. However, the strong interaction between photoperiod sensitivity and temperature has complicated attempts to predict optimal photoperiod responses for different bean growing regions. Approaches being used to clarify this problem include retrospective studies, modeling of IBYAN results and use of an international adaptation nursery (IFAN).

In retrospective studies of photoperiod response of IBYAN materials, traditional and newly released varieties, preliminary analyses suggest that the basic evaluation system (based on the 1 to 9 scale of delay in flowering) does predict some level of photoperiod adaptation. Conjectures concerning photoperiod response examined were:

(1) For the average of all IBYAN trials within a year (and presumably seed group), the best yielding lines should be photoperiod insensitive, while the worst yielders should include more sensitive lines.

(2) If photoperiod sensitivity is an important part of local adaptation, then traditional or recently adopted varieties would be more photoperiod sensitive than IBYAN lines.

Comparing frequency distributions of the three best, the three worst lines, and all lines from IBYAN's from 1976 to 1982, the best yielding lines differed significantly from the lowest-yielding lines in having a high proportion of photoperiod insensitive lines (Table 53). The worst-yielding lines appeared to have a greater proportion of sensitive lines, but failed the significance tests. And when IBYAN lines, traditional varieties, and recently released varieties were compared (Table 53), there were no significant differences in frequency of photoperiod sensitivity, suggesting that the IBYAN lines are fairly similar to the varieties CIAT is attempting to improve upon.

To further test the photoperiod screening system, data from IBYAN trials were used to characterize the photoperiod responses of 13 lines. Besides time to maturity, data for mean temperature from planting to flowering (Tpf), from flowering to maturity (Tfm), and from planting to maturity (Tpm), effective photoperiod at 20 days (PP20), and a photoperiod-temperature interaction (Tpf*PP20) were used. The models were:

Model A1 -- PM = f (Tpm)
A2 -- PM = f (Tpm, PP20)
A3 -- PM = f (Tpm, PP20, Tpf*PP20)
Model B1 -- PM = f (Tpf, Tfm)
B2 -- PM = f (Tpf, Tfm, PP20)
B3 -- PM = f (Tpf, Tfm, PP20, Tpf*PP20)

(See Table 54.). For the simplest model, Model A1, the percentage of variance explained ranged from 26% for G 4494 to 79% for G 4017. Addition of the photoperiod and photoperiod-temperature effects (Models A2 and A3, respectively) improved predictions, but the effect was variable, apparently reflecting varietal differences in photoperiod sensitivity. The simplest model using separate temperature responses for pre- and post-flowering periods (Model B1) gave the poorest predictions of all, while the best model combined the separate temperature responses with PP20 and Tpf*PP20 (Model B3).

The regression coefficient for the effect of photoperiod (Bp) averaged 3.2 between Models A2 and B2. This is consistent with beans being short day plants, and implies that for a hypothetical average bean variety, maturity is delayed 3.2 days for each one hour increase in length of photoperiod.

For the seven lines classed as photoperiod insensitive (score of 1 in the CIAT system), G 76 (Redkloud-1) and G 4459 (NEP 2) differed from the other lines in having much larger responses to photoperiod as indicated by improved prediction in models with PP20, and the relatively large values of Bp. Since prediction of maturity was further improved for both lines by inclusion of Tpf*PP20 in Model B3, it is likely that while the varieties are insensitive at CIAT, they become sensitive under other temperature regimes.

Looking at photoperiod sensitive materials (score of 3 or 4 in the CIAT system), photoperiod responses were generally stronger as indicated by increased accuracy of predictions with inclusion of PP20 in the models, and by the larger regression coefficients for PP20. However, by these criteria, BAT 302 would appear to be insensitive, Bp averaging 2.4, and the more complex models giving no improvement in prediction. G 4494 (Diacol Calima) stands out as highly sensitive, while G 3353 (Puebla 152) is remarkable for its large photoperiod-temperature interaction.

This partial confirmation of the utility of the screening data coincides with previous modeling efforts at CIAT (Bean Program Annual Report, 1980) and comparisons of photoperiod responses at Pasto, Popayan and Palmira. While the CIAT-Palmira evaluations appear useful, better predictions of time to maturity or adaptation would be obtained with supplemental evaluations under other temperature regimes.

International Flowering and Adaptation Nursery (IFAN). Although data from multi-site trials such as the IBYAN's have great utility in adaptation, the variation in photoperiod response of the materials limits their usefulness. For this reason, the IFAN was developed in collaboration with Cornell University. The IFAN contains 50 lines which previous studies indicated represent the complete range of variation in photoperiod responses. To date, nurseries have been sent to six countries.

Criteria for Evaluating Materials. It is frequently noted that researchers vary in criteria used to judge physiological maturity, some emphasizing loss of pod color at the onset of pod drying, others preferring the stage when 90% of the pods are dry. A comparison of evaluations of physiological maturity in 72 lines indicated that four observers using the two criteria can differ in as much as 15 days for the same bean variety. However, there was little difference in the accuracy of prediction judged by the correlations with the mean of all evaluations of maturity or with seed yields (Table 55). The second criterion resulted in an average of 3% higher 100 seed weight and resulted in slightly better correlations with yield, and thus would appear to be the preferable criterion.

Observer bias was marked (as indicated by differences between mean estimated times to maturity and variances for maturity) but it could not be concluded that one observer was consistently better than the other. Thus it is important to maintain the same observer for a single trial, and to use caution in comparing data from different observers.

Table 53. Frequencies of photoperiod responses of bush bean lines from 1976 to 1982 IBYAN's, and traditional and recently released bush varieties. Groupings of the best and worst yielding lines are based on mean yields of the three extreme lines counting duplicate entries only once. Significance test is for frequencies differing from all lines in the IBYAN's.

	Frequency of photoperiod response						
Group of materials	1	2	3	4	4	Total	Probability
1976 to 1982 IBYAN's							
All lines	34	13	24	9	6	86	--
Best-yielding	17	2	4	1	1	25	.01
Worst-yielding	12	4	3	8	4	31	NS
Traditional varieties	14	3	5	1	0	23	NS
Recently released varieties	8	1	5	2	0	16	NS

Table 54. Percent of variance in time to maturity explained by linear models predicting duration of growth cycle. Models are described in text.

PR = photoperiod response evaluated at CIAT.

Bp = regression response on photoperiod at 20 days for models A2 and B2, respectively.

Line	PR	Model				Model			
		A1	A2	A3	Bp	B1	B2	B3	Bp
BAT 58	1	58	57	57	2.6	55	54	57	2.6
G 76	1	34	39	37	4.1*	29	41	52	4.6*
G 3645	1	55	56	55	1.8*	53	55	57	2.0*
G 4017	1	79	78	77	2.1*	76	77	77	2.5*
G 4445	1	58	58	56	2.0	55	56	55	2.2*
G 4459	1	58	64	63	3.9*	55	64	71	4.2*
G 4525	1	56	57	57	2.3*	54	55	57	2.2*
BAT 302	3	52	49	53	2.5	52	51	52	2.2
G 3353	3	43	58	56	5.4*	39	57	69	5.7*
G 3807	3	58	54	53	2.7*	50	55	59	2.8*
G 4495	3	58	64	62	3.8*	55	62	66	3.9*
BAT 332	4	59	57	52	2.9	48	52	58	3.4*
G 4494	4	26	45	46	6.3*	24	47	51	6.5*
Mean		53ab*	57cd	56bc	3.1	50*	56bc	60d	3.3

* = Regression coefficient greater than 0 at p = 0.05 level.

\+ = Means followed by the same letter are not different at p = .05 level.

Table 55. Evaluations of time to physiological maturity by different observers.

Criterion	Observer	Days to maturity		Correlation with	
		Mean	Variance	Overall Mean	Seed yield
Pod color change	1	61.1	17.4	.950**	.379**
	2	57.8	5.0	.974**	.289**
	3	57.8	18.8	.974**	.357**
	4	59.6	18.1	.947**	.390**
	Mean	59.1	9.6	.992**	.387**
Dry pod walls	1	65.6	11.6	.895**	.326**
	2	62.7	12.2	.976**	.353**
	3	62.8	12.6	.970**	.313**
	4	64.6	3.7	.956**	.283**
	Mean	63.9	12.0	.992**	.341**

** = $p \leq .01$

h. Cell Membrane Stability

Both temperature and drought adaptation are thought to involveprocesses related to cell membrane stability. A simple test for evaluating stability is to expose 1 cm leaf discs to an appropriate stress (heat, cold or water), leave them for a period in distilled water, and measure the increase in conductivity caused by leaching of cell contents through the damaged membranes. Since samples vary in total cell contents, results are corrected by determining the total cell contents (taken as conductivity after freezing or autoclaving to destroy all membranes), and calculating damage score as:

$$\text{Membrane damage} = \text{Arcsine}\left(\frac{\text{Treatment conductivity}}{\text{Post-freezing conductivity}}\right)$$

In a series of preliminary experiments, it was determined that:

(1) Freezing discs produces fewer artifacts than autoclaving.
(2) Leaf discs give more uniform results than individual leaves.
(3) Damage varies with leaf age.
(4) For beans grown under field conditions at CIAT, a 40°C, 30 minute treatment provides a useful range of damage.

In comparison of 12 lines representing groups identified for cold, drought or heat tolerance (based on information from the 1979 and 1982 Bean Program Annual Reports), cold tolerance was associated with greater membrane damage, and heat tolerant materials showed the least damage (Table 56). Drought materials occupied an intermediate stage, suggesting that this group is not unusually heat tolerant, as some researchers had hypothesized.

In a comparison of 12 lines selected to represent a range of drought tolerance, the membrane damage score averaged over both drought and irrigated control plots appeared to have an optimum near .54 as compared to the geometric mean of yields from the two treatments (Figure 12). If the line which matured in 58 days (A 59, assumed to have escaped drought through early maturity) is excluded from the regression, a quadractic equation fits the data with $R^2 = .89$.

These preliminary data suggest that membrane stability or related techniques may provide a powerful tool for screening germplasm for temperature adaptation or drought tolerance. The technique is non-destructive, could easily be standardized, and appears to measure a basic characteristic of plant response to environment.

Table 56. Results of membrane damage scores for 12 lines for tolerance to cold, drought, and heat.

CIAT no.	Name	Damage score
Cold tolerant:		
G 5772	Diacol Andino	0.76 a*
G 4523	ICA Linea 17	0.69 ab
G 8042	Renka = GLP 1	0.68 ab
G 5701	Rojo 70	0.67 ab
Drought tolerant:		
BAT 85		0.63 bcde
BAT 477		0.63 bcde
BAT 336		0.61 bcdef
A 54		0.50 cdefghi
Heat tolerant:		
G 3689	S-315-N	0.64 bc
G 5213	Brazil 1096	0.55 bcdefg
G 4461	Porrillo 1	0.54 cdefgh
G 2525	Magdalena 3	0.47 cdefghi

* Scores followed by the same letter(s) do not differ at p = 0.05 of the Duncan Multiple Range Test.

i. Tolerance to acid soils

At Quilichao, selection continues of bean germplasm tolerant to acid soils under low phosphorus and high aluminum conditions.

As in the previous year, a three stage screening system was structured for bean lines from the Central American adaptation nurseries, bean golden mosaic (BGMV) lines, pre-VEF lines and advanced lines of the EP 84. In stage I, the materials were planted with 1 t/ha of dolomitic lime plus 26 kg/ha of P (60 kg/ha of P_2O_5); in the second stage, with 800 kg/ha of dolomitic lime plus 17 kg/ha of P (40 kg/ha of P_2O_5).

The III stage was planted to bean lines which had shown tolerance i.e. satisfactory adaptation and yields in the two previous stages. In stage III, the lines were subjected to phosphorus stress with only the addition of 9 kg/ha of P (20 kg/ha of P_2O_5) and aluminum stress (greater than 50% Al saturation) with the addition of only 400 kg/ha of dolomitic lime. The screening was done in random blocks with four replications grouping the materials by growth habit and grain color, and was protected against diseases and pests.

Table 57 presents the results of the bean lines which were simultaneously efficient in using P and tolerant to Al stress or tolerant to acid soils. The average dry bean yield. (at 14% moisture content) of the materials tolerant to acid soil are at the level of the controls, Rio Tibaji and Carioca.

Table 57. Average yield in kg/ha at 14% moisture content of bush bean lines tolerant to acid soils in Quilichao, 1984A.

Line	Yield			$\mathcal{L}$	β
	Without stress kg/ha	P stress kg/ha	Al stress kg/ha		
NAG 60	2335	1166	1082	4.6	20.8
BZ 4605-1	2042	1150	1102	3.5	15.6
A 440	1843	1110	781	2.9	17.7
A 254	1872	1011	1069	3.4	13.3
A 257	2064	1006	1406	4.2	10.9
BZ 729-1	2021	906	1311	4.4	11.8
Carioca[a]	2313	1309	1189	4.0	18.7
Rio Tibaji[b]	2252	965	1055	5.1	19.9
C. V. (%)	8.2	13.6	15.8	15.5	25.8

$\mathcal{L}$ = Additional response to applied phosphorus.

β = Additional response to applied calcium.

j. Increased N_2 Fixation

Strain collection and testing. Strains of *Rhizobium phaseoli* were isolated from nodules on BAT 1297 grown in association with coffee on farms in the departments of Caldas and Risaralda. *Rhizobium* had not been previously collected from this bean-growing region of Colombia . Forty-five strains were purified and tested for effectiveness with BAT 76 in Leonard jars. A number of them proved to be highly effective (Figure 4) and these will be further tested in plant-soil systems to evaluate their ability to survive and compete in the soil against native *R. phaseoli*.

A number of herbicides, insecticides and fungicides are used in field and glasshouse experiments. The effect of eight of these on the growth and survival of six *Rhizobium phaseoli* strains was examined because of the concern that these compounds may be inhibitory and thus limit nitrogen fixation. The six strains (CIAT 166, 255, 407, 632, 640 and 899) were all resistant to Elosal, Bravo 500, Derosal, Azodrin, Kelthane, Tamaron, Piltran, and Afalon at the recommended concentrations used in the sprayers.

Breeding for enhanced nitrogen fixation. Breeding for enhanced nitrogen fixation in agronomically acceptable bean cultivars was continued using the recurrent selection and intermating scheme described in the CIAT Bean Program Annual Report 1983. During the 1983B growing season 58 elite families were evaluated in replicated yield trials in Popayan, Santander and Palmira. Grain type, maturity, disease reaction, vegetative vigor (root and shoot weight), yield, and nitrogen fixation (acetylene reduction and nodule weight) at flowering were considered. Following an evaluation in sand culture in the glasshouse to confirm nitrogen fixing potential, 25 lines were selected for the VEF/84 and coded RIZ 30 to RIZ 54. Also in 1983B, 934 F_3 and F_4 families were progeny tested in Popayan and Palmira. Seventy-five uniform elite families were selected on the basis of grain type, vegetative vigor, and reproductive score. These materials were yield-tested in the three locations in the 1984A season and the rank orders of some outstanding lines, for a number of different characters, are listed in Table 58. When compared to the best checks from earlier cycles of selection these entries showed improved performance for several to all of the characters examined. However, there was little relationship (yield $r= 0.26$, shoot wt. $r= 0.22$, nodule wt. $r= 0.09$) between performance at Popayan and performance at Santander.

Seven hundred single plant selections of F_2 populations, evaluated in Popayan in 1983B, were progeny tested in Popayan and Palmira in 1984A. In addition 90 F_2 populations, from an extensive array of parents (including climbers for the first time), were evaluated in Popayan in 1984A.

The inability to routinely measure nitrogen fixation directly has been one of the severe limitations to research in this area. The correlations between fixation and associated characters, such as nodulation, vigor, and yield in low N soils, are variable and difficult to assess. Also, the correlations between the different characters are often poor as demonstrated by the results of the 1984A yield trial in Popayan (Figure 5). Thus, nitrogen-fixing ability is currently being estimated using the combined data of these different characters. In addition a visual nodule scoring system (Figure 6) for routine use in the field which takes into account nodule size and color is being evaluated. This scoring system should prove useful as nodule weight and acetylene reduction assays are time consuming.

A number of the RIZ lines (RIZ 10, RIZ 13, and RIZ 29) are performing well in international nurseries. They have high yield, good grain type, broad adaptation and some disease resistance, however, it is difficult to assess if they support more fixation and get a greater proportion of their N from fixation. To evaluate the progress of this breeding program for improved nitrogen fixation an accurate method of quantifying fixation, throughout the growing season, is needed. The ^{15}N isotope dilution method offers this possibility as soil, fixed, and fertilizer nitrogen, in the harvested portion of the crop, can be distinguished. A collaborative research project with Rothamsted Experimental Station, United Kingdom, has been set up making it possible for the ^{15}N isotope dilution method to be used for the evaluation of nitrogen fixation in the selected RIZ lines.

Table 58. Ranking of some outstanding lines evaluated for N_2 fixation and yield in Santander (San) and Popayan (Pop) in 1984A, as compared with the best checks from earlier cycles of selection. Results are reported as rank order within that particular trial.

Identification	Color	Nodule wt.		Root wt.		Shoot wt.		C_2H_2 red.		Yield	
		San	Pop	San	Pop	San	Pop	San	Pop	San	Pop
26 Entries											
RH 10521-2	White	11	9	17	21	15	21	16	7	26	6
RH 10515-9	White	3	20	3	18	8	24	19	21	11	10
RH 10584-3	Carioca	2	19	15	15	4	10	6	8	7	11
RH 10592-8	Carioca	14	10	8	1	12	1	10	14	6	12
RH 10595-1	Carioca	17	26	14	2	13	4	8	12	1	2
RH 10599-4	Carioca	9	6	19	2	13	11	12	22	9	8
RH 10601-8	Carioca	21	4	5	14	2	8	26	2	21	3
CHECK											
RIZ 22	White	25	14	25	24	17	25	22	9	4	17
21 Entries											
RH 10544-2	Mulatinho	2	3	7	1	8	3	12	11	8	2
RH 10589-11	Yellow	18	12	8	8	2	1	16	10	16	4
RH 10602-3	Yellow	4	4	1	11	10	4	4	2	14	8
RH 10633-2	Yellow	17	11	15	18	1	9	13	3	1	1
RH 10611-6	Cream	14	7	5	2	9	2	17	4	13	11
CHECK											
RIZ 29	Mulatinho	3	8	9	3	3	5	1	6	19	7
31 Entries											
RH 10600-4	Red mottled	14	23	14	12	21	7	1	15	13	11
RH 10600-12	Red mottled	17	12	23	7	15	14	4	8	23	5
RH 10543-6	Black	18	18	16	1	22	3	19	3	15	1
RH 10620-3	Black	7	13	2	14	2	10	20	26	8	4
RH 10622-4	Black	4	27	4	6	7	2	16	24	6	13
RH 10624-1	Black	6	14	17	10	1	4	10	23	5	3
RH 10625-5	Black	30	16	8	13	3	12	2	22	2	6
CHECKS											
BAT 1645	Red	13	31	30	30	30	25	21	27	18	31
RIZ 13	Black	11	26	3	21	5	11	8	12	9	14
BAT 76	black	8	19	20	8	27	23	17	11	28	21

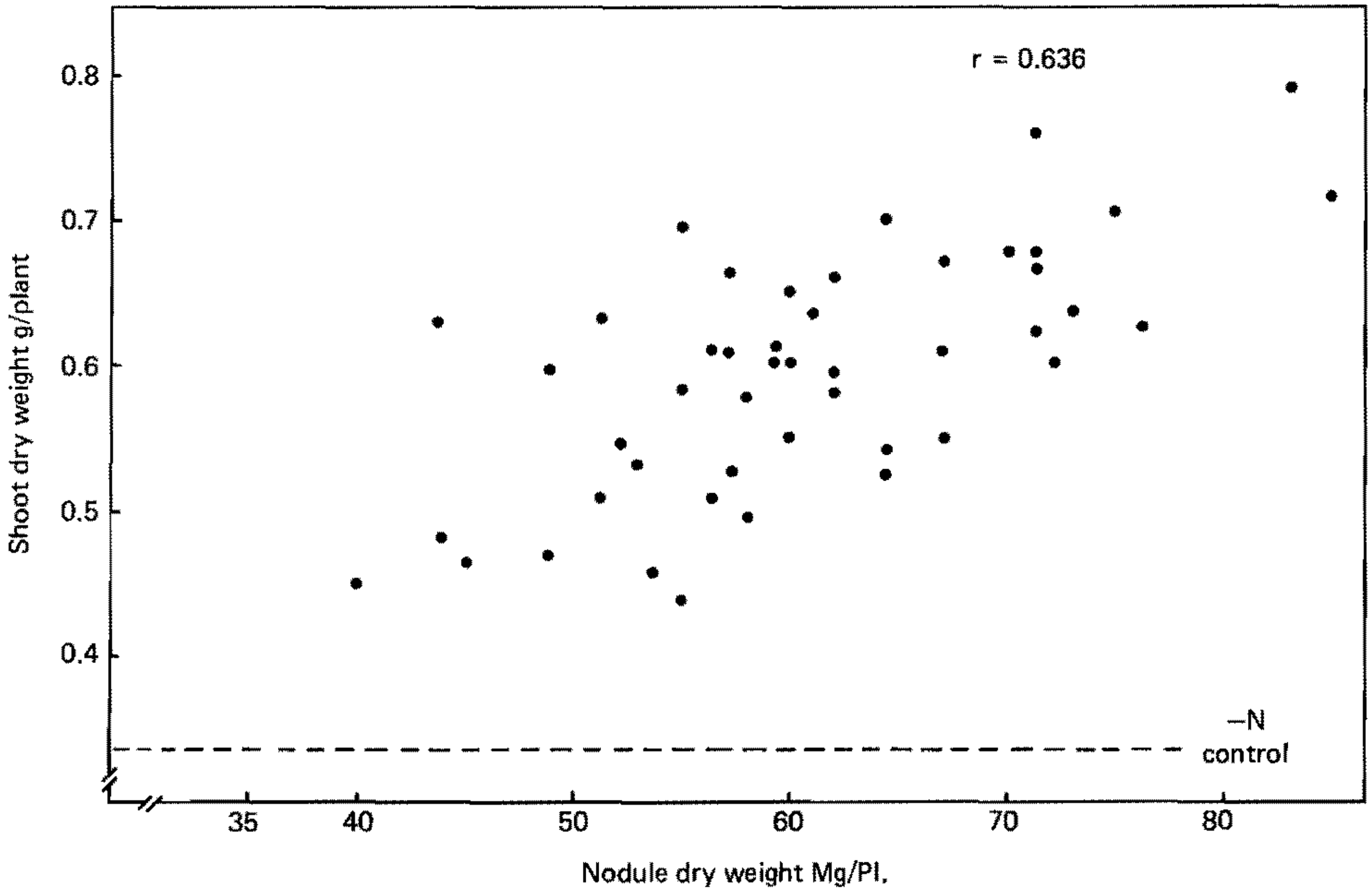


Fig. 4 : **Correlation of shoot dry weight with nodule dry weight in BAT 76 inoculated with different strains of *R. phaseoli* in Leonard Jars (shoot wt. of + N control = 2.1 g/plant.**

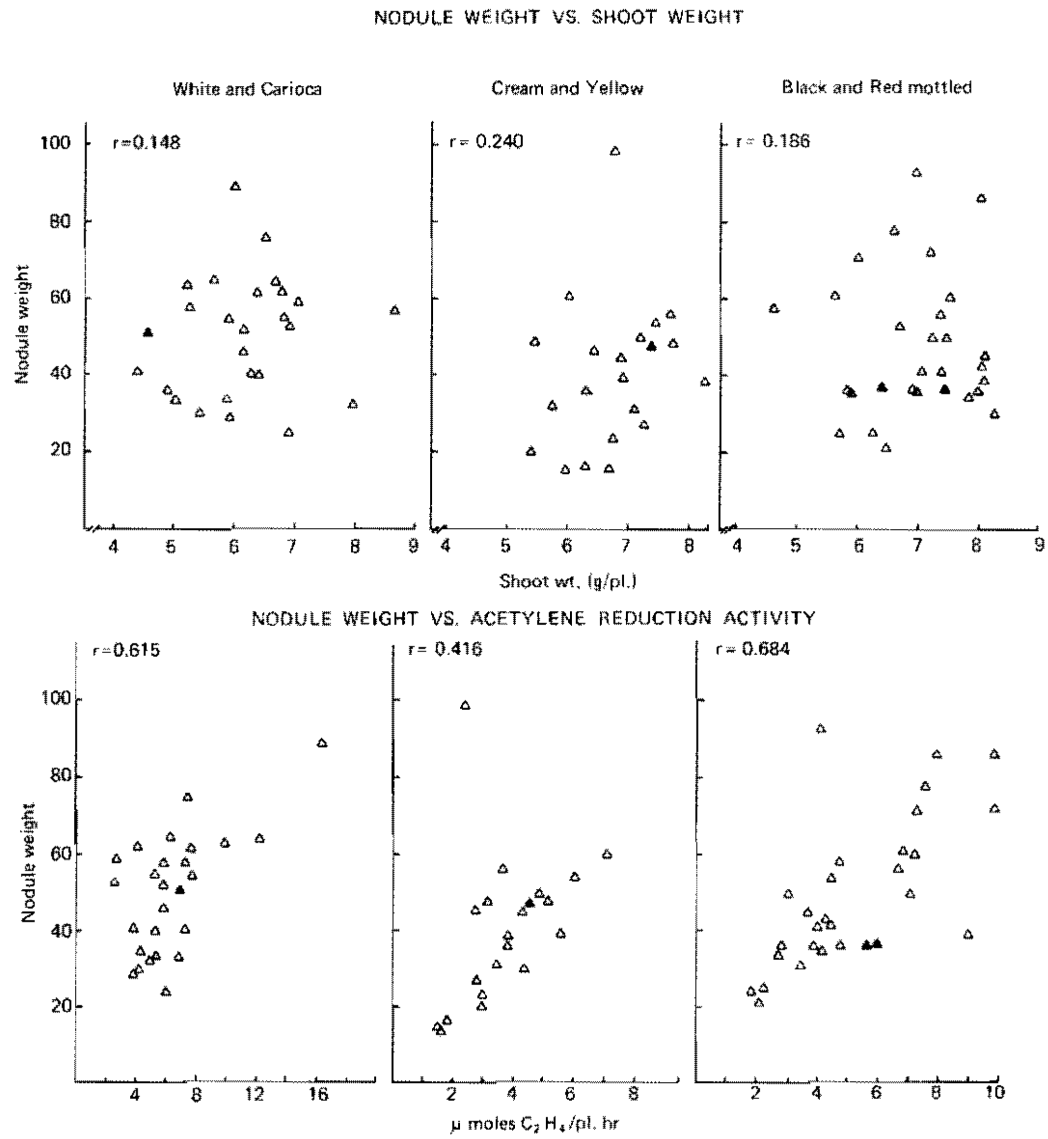
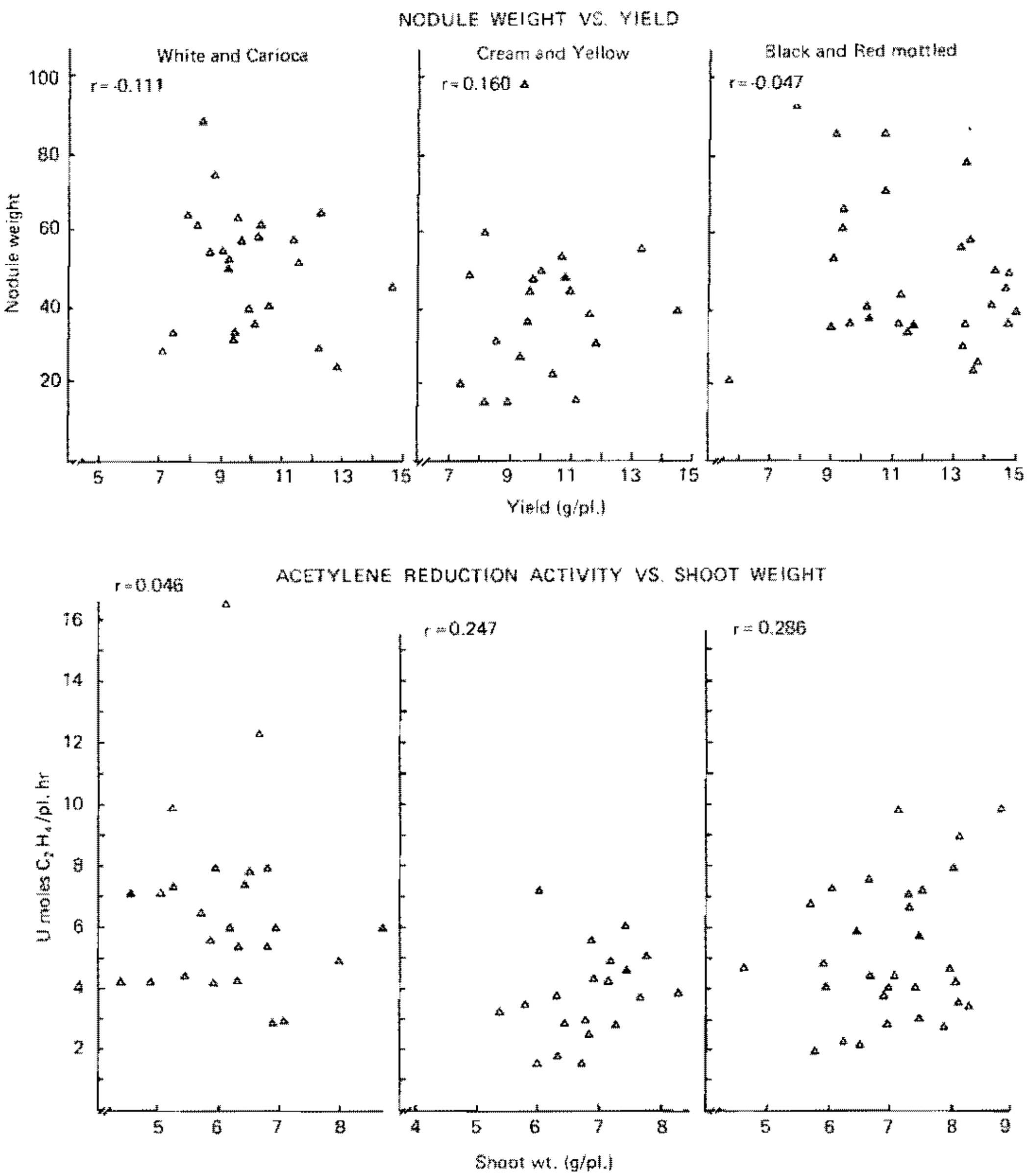


Fig. 5: Correlations between characters used to estimate nitrogen fixation potential. Popayan 1984A. Best checks from previous cycles of selection.

Fig. 5. (Continuation).



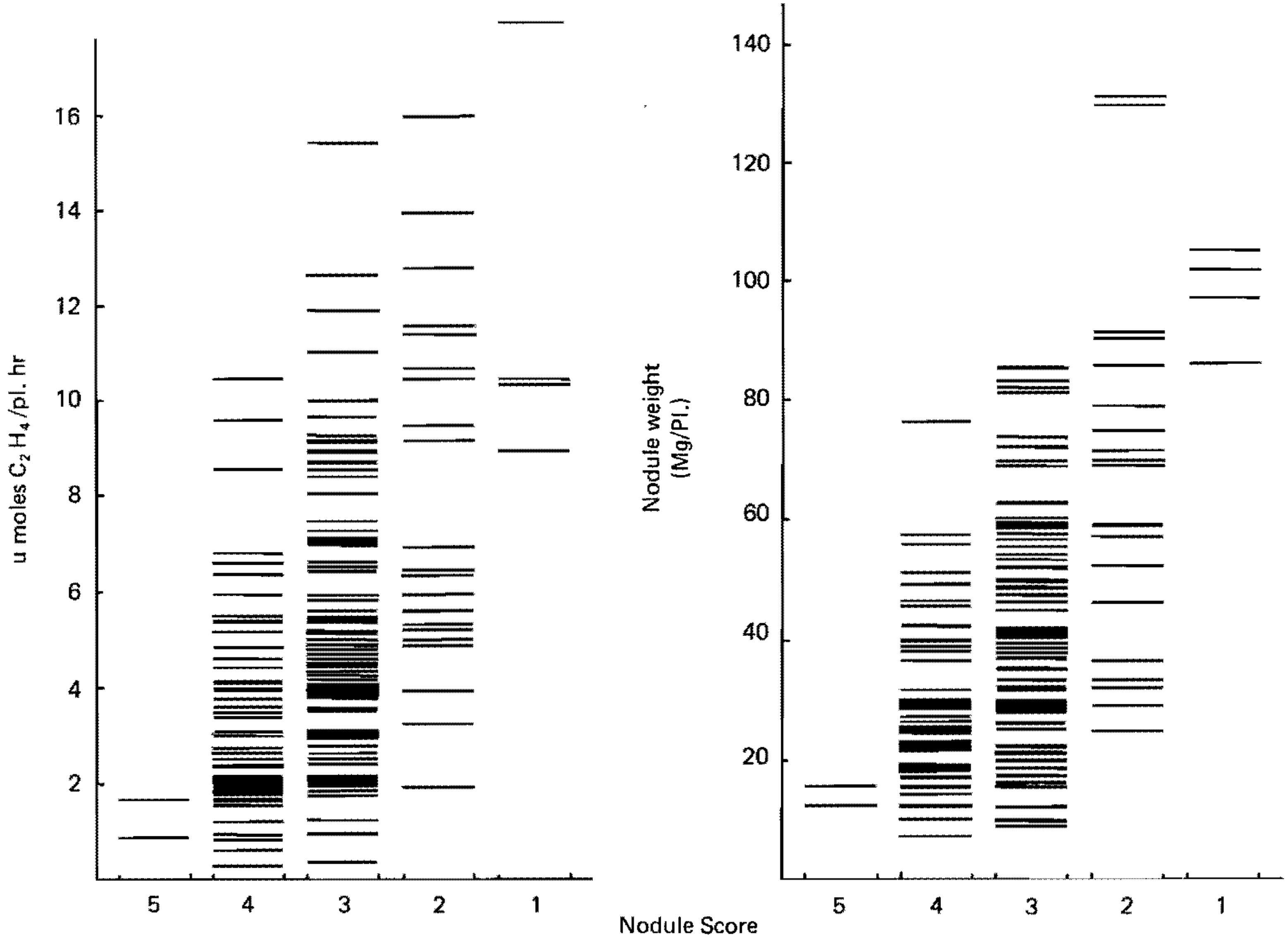


Fig. 6: Evaluation of visual nodule scoring system for routine use in the field.

k. Variability from Interspecific Hybridization

P. vulgaris x P. coccineus yield trials. During 1984, several types of interspecific crosses between *P. vulgaris* and *P. coccineus* generated in the collaborative project with the University of Gembloux, Belgium, were tested in preliminary yield trials to evaluate their yield potential (Table 59).

Previously, the early generations of these crosses were submitted to several cycles of single plant selections for resistance to *Ascochyta* and for yield per plant (minimum 300 seeds). The advanced progenies were tested to compare their average yield per plot with that of E 1056 a *P. vulgaris* elite line. They were sown with maize at a density of 53,300 plants per hectare and bulk harvested after 135 days. Table 60 summarizes the crosses that were selected among those tested and their respective yields.

Significant differences occurred between the crosses tested and among sister lines for traits such as yield, disease resistance, vigor, plant architecture, raceme length and structure, seed color, etc. Segregation within the same cross is often considerably reduced after 3 or 4 cycles of single plant selection, depending on the parental combination and the site where the progenies are grown. In Popayan, the cross pollination is low whereas in Rio Negro the activity of the bumblebees, carpenter bees and humming birds, causes a continuous recombination of the caracters of the hybrids.

All the sister lines of the cross NI 552 x G 00677 x Piloy x A 133 are resistant to *Ascochyta*. It seems that the use of the subspecies *formosus* as a bridge between *P. vulgaris* and *P. coccineus* maintains the good level of resistance to *Ascochyta* through successive generations. However, takes longer to stabilize the other characters of this four-way cross. Their progenies segregate for yield, resistance to rust, angular leaf spot, *Oidium* and vegetative vigor. One uniform line was selected with medium size black seeds, which yielded equally whether protected or not. This line is highly resistant to *Ascochyta* and rust, and tolerant to angular leaf spot and *Oidium*.

G 04459 x PI 165 421 x Guate 1240 is a cross which is highly variable for all characters recorded. One line from this cross was high yielding although its vigor was depressed and it was susceptible to *Ascochyta*. The second line selected, with red seeds, was vigorous, resistant to *Ascochyta* and *Oidium* but susceptible to rust.

All the sister lines of Cargamanto x 88-1 were tolerant to *Ascochyta*, showing mild viral symptoms and most of them yielded poorly although one productive progeny was selected.

Simultaneously, all the lines listed in Table 59 have been screened in various Andean stations and single plants were selected up to the F_7 generation and back-crossed to various *P. vulgaris* elites at different stages of the process.

P. acutifolius x P. vulgaris nurseries. Three successive generations (C_3 to C_5) of the tetraploid hybrid *P. acutifolius* x *P. vulgaris* have been grown in the field at CIAT-Palmira. Resistance close to immunity to bacterial blight was identified in the cross G 40034 x Bico de Ouro. High levels of resistance to rust have been observed, although this character seems to be more variable.

The tetraploid populations are uniform as far as plant morphology is concerned in the early generations (C2, C3). Individuals with different flower and seed color and leaf morphology have been selected in the C4 and C5. All populations segregate for fertility and yield.

P. coccineus multiplication nursery at Rio Negro. Some 330 accessions from the *P. coccineus* collection have been planted in the field in Rio Negro for evaluation and seed multiplication. Half of the accessions belong to the subspecies *coccineus* and the other half to *polyanthus*. Open pollination was prevented by wrapping the raceme in a paper bag. Approximately four buds per raceme can be hand-pollinated at the same time and this method has proved successful for obtaining seed for germplasm conservation. Seed from open-pollination is now available for distribution to collaborators. The *coccineus* collection shows a wide array of plant types from bush to climbers, from vigorous perennials to precocious lines which are agronomically similar to some *P. vulgaris* varieties.

Table 59. Interspecific crosses submitted for yield trials in Popayan.

Species crossed[a]	Parents	Generation
(PV x PCc) x PV	G 04459 x PI 165421 x Guate 1240	F_4
(PV x PCc) x PV	G 04459 x PI 165421 x BAT 1274	F_4
((PCf x PV x PCp) x	PVNI 552 x G 00677 x Piloy x A 133	F_4
PV x PCp	BAT 788 x Guate 909	F_5
PV x PCp	Guate 1088 x Piloy	F_6
PV x PCp	Mortiño x X7	F_6
PV x PCp	BAT 338 x Guate 909	F_6
PV x PCp	San Martín x Piloy	F_6
PV x PCp	Ecuador 299 x Piloy	F_6
PV x PCp	G 5066 x Piloy	F_6
PV x PCc	Ecuador 51 x 88-1	F_5
PV x PCc	Cargamanto x 88-1	F_6
PV x PCc	Mortiño x 88-1	F_6
PV x PCc	Coco white x PI 176672	F6

[a] PV = Phaseolus vulgaris
PCc = Phaseolus coccineus sub sp. coccineus
PCf = Phaseolus coccineus sub sp. formosus
PCp = Phaseolus coccineus sub sp. polyanthus

Table 60. Yield of selected interspecific progenies in Popayán.

Progenies	Yield (kg/ha) protected	Yield (kg/ha) non protected	Seed color	Seed weight (gr/100 seeds)
(G 04459 x PI 165 421) x BAT 1274	933	1169	Red	31
(G 04459 x PI 165 421) x BAT 1274	1162	1014	Black shiny	28
((NI 552 x G 00677) x Piloy)x A133	876	973	Black shiny	28
Cargamanto x 88 - 1	1237	813	Black	29
E 1056	1264	837	Red mottled	48

1. Evaluation of Quality Characteristics

The principal activities carried out in the nutrition and quality laboratory are as follows:

(1) Evaluation of 390 advanced lines from the Preliminary Yield Trial EP/84B. (See chapter 3.3 for the full composition of the EP.)

(2) Study of the influence of location, harvest time, and crop variety on the cooking time, seed hardness and crude protein content.

(3) Evaluation of cooking time and hardness of wild lines of the common bean, resistant to storage insects.

Routine evaluation of the EP/84

The following characteristics were evaluated: seed quality; percentage of water absorbance from dry weight; presence of hard and broken grains; average cooking time and soup quality (percentage of solids), and protein content.

The same methodology was used which was described in the Bean Annual Report for 1982.

The seed was obtained in the second semester, harvested in Palmira. Because of the lack of seed, replications of the analysis could not be done, therefore, only comparisons among groups were carried out and lines within the groups were considered as replicates.

Results of the analyses

The average values of the characteristics measured in 1982 and 1984 were similar with the exception of cooking time and water absorption, Table 61.

For all the characteristics evaluated, some groups were significantly different from others with the exception of cooking time and protein content in 1984.

The percentage of water absorption in group 20 was significantly less than in the other groups for both years. At the same time, this group had the greatest hardness in both 1982 and 1984. The percentage of seed hardness and water absorption have a highly significant negative correlation (-7, -.7), respectively. In group 10, the small blacks liberated a greater quantity of solids in the broth, while group 35 (white large/medium bush beans) produced the least solids for the two years.

In 1984, group 70 had the lowest protein content while in 1982 it was among the highest. For cooking time and percentage protein there was no single tendency among the groups. As in past years, correlations were observed among several grain characteristics and culinary factors, Table 62.

The shiny grains tended to resist absorbing water during soaking. They also differed from the other tones in the time required for cooking, tending to take longer and be harder. The opaque colors presented less seed hardness. There were no significant differences in the percentages of solids among the tones.

It was also found this year that seed size can influence some cooking characteristics of the seed (Table 63). Apparently, the size of the grain can influence the liberation of solids in the broth and the cooking time. In 1982, there was a highly significant and negative correlation of -.5 between the seed size and the percentage of solids. This same tendency was observed in 1984.

In 1981 as well as in 1982 where was a slightly positive but significant correlation between the seed size and the cooking time (.24 and .23, respectively). As a result, large-seeded beans can take a slightly longer time to cook than the smaller grains (hard seeds were not evaluated for cooking time).

Comparative study on the influence of site, harvest time and variety on cooking time, hardness and protein content

The objective of this study is to determine if genetic or environmental variability, or the interaction of the two can influence some cooking and nutritive seed characteristics.

Standard varieties must be identified which are representative of the characteristics to be measured. From the results of this study an appropiate sampling system will be established and an evaluation begun of the feasibility of initiating breeding projects for quality characteristics.

Thirty lines of different types of grains from the EP 84 were chosen, the five best and the five worst for percentage protein content, cooking time and hardness (Table 64). These will be planted in Palmira and Popayan over four seasons.

Evaluation of wild lines of beans resistant to storage insects.

Cooking time was measured in nine resistant lines and five susceptible ones and the percentage hardness measured in 18 resistant lines and five susceptibles ones (Table 65). There were no significant differences among the lines for any of two variables. The range in cooking time for the resistant lines was 18-76 minutes.

Table 61. Comparison of averages for the characteristics measured in the EP/82 and 84 among all groups.

Characteristics	1982	1984
% water absorption	99.7 ± 11**	84.4 ± 22**
% hardness		9 ± 20.1**
Cooking time (min)	21.6 ± 5**	25.9 ± 6
% solids in the broth	10.2 ± 3**	9.93 ± 4.8**
% protein content	21.0 ± 2**	21.2 ± 2.1

** Significant differences among groups P < 0.01.

Table 62. Influence of tone on water absorption, seed hardness, production of solids in the broth, cooking time and protein content.

Tonal category	% water absorption	% hardness	% solids	% protein (min)	% Time (min)
Shiny	83.62*a	14.18*b	9.77c	20.89d	26.75*e
Semi-shiny	91.12	6.38*	9.86	21.33	24.96
Opaque	96.28	0.21*	10.34	21.98	24.95

* p < .05
a = The same in 1980, 1981, 1982
b = The same in 1982 (not measured in 1980 or in 1981).
c = NS in 1981. In 1982 opaque seed had greater significance
d = NS in 1982.
e = The same in 1980 y 1981

Table 63. Influence of seed size on cooking time and solids in the broth in 1984.

Size	% solids in broth	Cooking time (min)
Big	8.08	28**
Medium	9.28	26
Small	11.03**	25

** P < .01

Table 64. Thirty advanced lines chosen from the EP/84 according to their characteristics for comparative trials.

Hard seed		Cooking time		% Protein	
Less	Greater	Less	Greater	Less	Greater
NAG44	RAB 9	Can 12	PAD 765	PAD 12	ZAV 8369
RAO 11	RAB 23	V8344	ZAV 8358	ZAV 8341	BAN 6
PVAD 875	PVAD 908	ACV 8316	ZAV 8398	ACV 8351	FEB 15
V 8360	PVAD 1046	WAF 5	PAI 12	PVAD 1408	XAN 135
ACV 8304	PAI 80	NAM 9	FEB 13	NAG 12	BAT 1714

Table 65. Average cooking time and percentage hardness in wild lines resistant to storage insects.

Susceptibility to storage insects	Cooking time (min) $\bar{x}$	% Hardness $\bar{x}$
Resistant	37	59
Susceptible	31	22

3.2 Character Deployment

a. Central America, Coastal Mexico, Peru, the Caribbean, and Black-seeded types.

The first uniform Adaptation Nursery (VA) was distributed in 1983 and the results summarized in 1984. The VA is now a successful and established part of the VA-VEF-EP-IBYAN system, and has provided a needed mechanism for interchanging more experimental lines between national and international programs. The 1984 VA contains selected landraces and hybrid selections from national programs, which provide valuable information for the deployment and continued genetic improvement of those materials, also, many character donor lines from projects of regional interest, but with inadequate overall agronomic value to merit EP selection, are being more widely tested in the target area via the VA.

A summary of the VA/83 is presented in Table 66. For the small black opaque grain type, results from Central America, Chile and the Caribbean assure that a broad sample of locally-adapted and broadly-adapted genotypes are advanced to the VEF and EP. In the case of medium-sized whites for Peru and Chile, the data from those countries is much more relevant than data from Colombia, which lacks a similar test environment. For the Caribbean, which represents a complex of ecosystems, testing for wide adaptation is essential.

The VA. nurseries have also served to help clarify several mutually exclusive bean ecotypes for the Central American production systems, and with important differences in plant growth habit and maturity. Strong regional programs like the Central American network have capitalized on the flexibility of the VA to identify high priority lines for the VEF, EP, and crosses. Most of the crosses for Latin American grain types are currently planned with students and scientists from national programs, principally on the basis of data from the VA, EP, and IBYAN.

Central America, small red. Excellent grain size and color is now abundant. Cooking time and texture is being evaluated because this class is inherently high in polyphenolic substances and tends to exhibit the "hard seed" phenomenon. Subtle differences in local cropping systems are very important for varietal acceptability, especially for maturity, plant type and grain color. Higher levels of resistance to CBB, BGMV, *Apion*, and web blight are being sought in different combinations. A special project has been initiated to improve the popular and high-yielding Rojo 70 for cooking quality and BCMV resistance. Numerous landraces are being used in crosses and backcrosses to broaden the genetic base and to improve the probability of obtaining local adaptation.

b. Caribbean grain types. This is the most diverse of the bean groups in terms of grain type, variable growth habits, and crop maturity. The most common deficiencies within this group are CBB and BGMV resistances. Hybrid progenies are being evaluated which combine intermediate levels of resistance to both pathogens with BCMV resistance and more acceptable grain type. Web blight, anthracnose, mildew, and rust resistance are of local importance for certain classes, while the most serious limitation currently is a lack of information on the rigidness of consumer and producer preferences for grain tone and size. The advantages of indeterminant growth habit (and smaller size) in terms of yield potential and yield stability have been observed in VA and IBYAN nurseries. (Some key resistance factors appear to be associated with indeterminacy and slightly darker grain tones). Until more complete information is available, numerous crossing projects are being undertaken to improve specific commercial grain types.

c. Small white (navy beans). A number of new lines combining grain quality, high yield potential, and good plant types are available, all resistant to BCMV and most to bean rust. Materials are being locally evaluated in Chile and Peru for reaction to rust races, *Empoasca*, BYMV, root rot complexes, and necrotic strains of BCMV. Much of the excellent germplasm developed in the United States and Europe adapts well and has been utilized as parents in the crossing program.

d. Medium-seeded whites. Production systems for this class, grown in Ecuador, Peru, and Chile, are unique and require careful definition of what constitutes an "improved" plant type. Excellent progress has been made locally in breeding for high-yield with good grain type and resistance to non-necrotic and NL3 strains of BCMV. Rigidness for grain size and tone is influenced by the export vs. domestic tradeoff and its priorities.

e. Canario and sulphur colors. Like the medium whites, these classes are generally fall/winter crops for which no Colombian location is adequate for evaluating adaptation. Most of the production is intensive and commercial, so that yield potential and production efficiency are necessary if beans are to compete with other crops. Mechanizable types are in demand, but the tradeoff between plant growth habit, maturity, and grain size again applies. Excellent progress has been made to transfer I-gene resistance to BCMV into a range of grain types. Resistance to locally severe races of rust and to *Empoasca*, and root rot pathogens is also a priority. Several traditional bean-growing areas reporting some of the highest yields in Latin America and the world will likely move toward higher value crops unless input efficient, high-yielding varieties are made available to growers.

f. Black grain type. Emphasis is on increasing levels of resistance to CBB and anthracnose in materials possessing earliness and resistance to BGMV, *Apion*, and web blight. Several countries are also interested in the high-yielding direct harvest types recently available. Selection for more stable rust resistance is receiving increased attention for several production zones.

Table 66. Summary of distribution and results of the 1983 VA, and distribution of the VA/84.

Color group	Entries planted	Data for No. entries	Checks	Entries evaluated	VA entries		
					To EP	To VEF	Locations
Black	10	10	20	90	25	24	18
Red	10	10	20	200	19	96	17
Navy	5	5	13	144	-	67	6
Medium white	5	5	6	28	-	8	6
Medium cream	7	5	20	236	-	36	9
Caribbean	8	7	22	234	49	70	14

Brazil (small, non-black beans for monoculture and intercropping). Part of 1984 was spent with CNPAF bean scientists to jointly review CNPAF-CIAT bean germplasm development activities both in Brazil and Colombia. It was concluded that the National Bean Testing Scheme of Brazil initiated by CNPAF in 1982, was now fully functional. Most institutions in major bean-growing states were participating in the network and enough experimental lines were available for testing in the second round of the biennial testing program beginning in August 1984.

From the experimental lines developed at CIAT and tested over the past several years in Brazil releases of new cultivars continued in 1984 (six cultivars released). Therefore, it was essential to assess future germplasm needs. It was decided to shift germplasm developmental responsability from CIAT headquarters in Colombia to CNPAF in Brazil to capitalize on local adaptation and to screen early generation materials for specific production problems especially those not occurring in Colombia. Thus, it is hoped that further genetic progress will continue beyond that of the newly identified cultivars. However, to expedite and complement the germplasm development activities, crosses (about 200 every two years) will be jointly planned and made at CIAT. Segregating F_2 to F_4 generations will be shipped to CNPAF once every two years for evaluation, selection and identification of desirable experimental lines. In 1984, the first group of about 200 crosses was planned. In the meantime, over 300 segregating hybrid populations from existing materials at CIAT were sent to CNPAF for evaluation and selection.

From the hybrid populations still being managed at CIAT, experimental lines of non-black seeds were developed. A total of 700 advanced but unfinished lines were shipped to Brazil in December. These are expected to enter in the CAM (Campo de Avaluacao Multidisciplinar) of CNPAF in February 1985. In many of these experimental lines of Mulatinho and Carioca types, resistances have been incorporated for anthracnose, angular leaf spot, common bacterial blight and drought. Also for the first time, several dozen lines of much needed Rosinha and Roxo types were available. Unlike existing commercial cultivars the latter carry resistance to BCMV and to other production limiting-factors.

Mexican Highlands (medium-seeded bayo, garbancillo, rosita, flor de mayo, pinto and ojo de cabra for monoculture and associated cropping). Steady progress was made in improvement of dry beans for highlands of Mexico. The first cycle of hybridization for improvement of climbing beans was completed. From the initial crosses made for monoculture beans, about 500 advanced lines were evaluated both in Colombia and in the highlands of Mexico, at four locations in each country. Several of these carried resistance to BCMV, anthracnose and other diseases. Most of these were Bayo, Pinto and Ojo de Cabra bean types. From early generation families of the latter crosses over 3,000 selections (F_3 to F_5) were made. Among these all principal bean types including Flor de Mayo, Garbancillo, Rosita (three difficult colors to achieve), Bayo, etc., were represented in adequate numbers for the first time. From the evaluations for BCMV, CBB, anthracnose, angular leaf spot and adaptation in Palmira, Quilichao and Popayan attempts will be made to reduce the number to about 1,000 for inclusion in the adaptation nurseries of 1985 for highlands of Mexico.

Based on the request of INIA scientists over 200 hybrid combinations were made in 1983/84 for Mexico. Each of these involved at least one commercial cultivar or germplasm bank accession originating from the Mexican highland. Donor parents carrying resistance to principal production limiting factors were utilized. Adequate quantity of seed of 200 crosses was sent to four locations for evaluation and selection by INIA scientists at Tepatitlan, Jalisco (for climbing beans for the humid highlands); Chapingo, Mexico (for bush and semiclimbing beans for humid highlands); Aguas Calientes and Durango (for monoculture beans for semi-arid highlands). Additional crosses were sent to Celaya, Guanajuato; and Saltillo, Coahuila. This was the first organized nursery of segregating hybrid populations sent to Mexico. Through the elaboration of this nursery on a routine basis it is hoped that the germplasm development process of INIA could be expedited and selections made for local adaptation and production problems not occurring in Colombia.

Argentina, West Asia, and North Africa (Medium and large white bush beans for monoculture). From the first group of crosses made in 1981 for genetic improvement of Alubia (large, cylindrical, white, determinate type I) of Argentina over 500 resultant F_4 and F_5 lines have been evaluated in Argentina en 1983, and about 300 selections were made. These were grown and evaluated in an adaptation nursery (VAPA) in Colombia and at five locations in the January-May season of 1984 in Argentina in collaboration with EEAOC and INTA legume scientists.

Of principal production limiting factors in Argentina, evaluations were made for web blight, angular leaf spot, anthracnose, common bacterial blight and virus problems (BCMV and others). The latter was more severe especially at Ceibalito and Moraleja in Salta province. All lines were found to be resistant in repeated tests for BCMV at CIAT and many also carried resistance to other fungal and bacterial diseases which was further confirmed by their performance in the fields in Argentina. However, reaction of these lines for other virus problems occurring in Argentina was not satisfactory. None of the lines was immune to the viruses, though marked differences were noted between materials. Since most of these lines were immune in 1983 evaluations, their performance in 1984 was disturbing. This could have occurred either due to increased pressure and/or appearance of new virus(es), strains, etc. In spite of these difficulties, scientists from Argentinian programs selected over 50 materials for further evaluations.

Also, both EEAOC and INTA scientists had made substantial progress in their local programs in developing lines with desirable bean types, and resistance to fungal and bacterial diseases. From over 300 lines of VAPA, 95 lines were selected for evaluation in the first adaptation nursery for West Asian and North African countries (WANABAN). This was a follow-up work on an agreement made during the workshop held in May 1983 at ICARDA, Aleppo, Syria.

The WANABAN was organized and distributed to all 12 countries of the region which had requested improved germplasm from CIAT. The nursery was evaluated at four locations in Turkey (Ankara, Eskisehir, Erzurum and Samsun) one of the largest producer and consumer countries of the region. There again viruses (BYMV, BCMV) were the most serious problems of beans both at the research stations and in farmers' fields. Over 40% of the lines had serious adaptation problems; good vegetative growth and flowering but little pod production and late maturing. Some problem of adaptation was expected since local cultivars from that region were not utilized in development of these lines nor were these materials evaluated at over 39^{o} latitude (longer days and shorter nights as compared to CIAT-Palmira. However, about 20 lines did as well or better than the local check cultivars, and were selected for further testing. Most of these had done well in previous evaluations at CIAT-Palmira and at different locations in Argentina. Due to increasing involvement in the West Asian and North African countries it became essential to incorporate parental cultivars from that region into the hybridization program at CIAT. As a result over 50 such parents from Turkey, Greece, Syria, Egypt, Iran, etc. were utilized in crosses in 1984. This considerably increased the number of bean types (large kidney, flat, and medium round) and production problems (drought, early maturity, cold tolerance, resistance to bean fly, BYMV, halo blight) beyond those of Argentina. Table 67 shows the number of experimental lines developed and new crosses made in 1984.

Further evaluations and selections were made in Colombia in most of these promising materials evaluated in VAPA and WANABAN in 1984, thus completing the first cycle of improvement of the cultivar Alubia which was initiated at CIAT in 1981. Performance of some selected lines is given in Table 67. These will be included in the IBYAN of 1985.

Table 67. Characteristics of some medium and large white-seeded experimental lines of dry beans from the first cycle of crosses evaluated in an adaptation nursery in 1984.

Identification	Growth habit	100 seed wt.	BCMV	BYMV[1]	CBB	Anthracnosis	Round leaf spot[a]	Adaptation COLOMBIA	Adaptation TURKEY	Adaptation ARGENTINA
ABA 2	1	42	R	3.0	4.5	S	2.5	3.8	4.0	4.3
WAF 3	1	42	R	2.8	4.0	V	1.5	3.0	4.1	3.0
WAF 4	1	24	R	3.5	2.0	S	1.5	2.9	4.1	3.8
WAF 5	1	29	R	3.0	2.0	S	1.5	2.8	4.0	3.0
WAF 8	1	25	R	3.5	4.5	S	3.0	3.5	4.3	4.0
WAF 9	1	46	R	2.8	4.3	R	1.5	3.5	3.6	4.0
WAF 11	1	59	R	2.5	3.5	S	2.0	3.5	3.5	4.3
WAF 12	1	45	R	2.9	4.0	S	3.0	3.5	3.8	4.3
WAF 13	1	37	R	3.0	4.0	S	1.5	3.3	3.8	4.3
WAF 14	1	48	R	3.3	3.0	S	2.0	3.4	3.8	4.3
WAF 15	1	48	R	3.8	3.5	S	1.5	3.4	4.1	4.0
WAF 16	1	50	R	2.8	4.5	S	2.0	3.6	3.5	4.5
WAF 19	1	36	R	1.8	5.0	S	2.0	3.4	3.6	4.8

[a] Evaluated under field conditions in Turkey

g. Eastern Africa

The principle problems for bean production in Eastern Africa, as enumerated in reports from individual countries that participated in the meeting on international nurseries held at CIAT from 26-29 November, 1984, include the following: variable rainfall (drought), low soil fertility and non-availability of fertilizers in some areas; bean fly, and bruchids; anthracnose, angular leaf spot, floury leaf spot, ascochyta, common bacterial blight, halo blight, bean scab, and BCMV. Of these problems, bean fly and bean scab do not occur on beans in Latin America, and the necrotic strains of BCMV which cause black root symptoms are more important in Africa than in Latin America. Production factors to be considered when developing a strategy for bean genetic improvement include the widespread use of varietal mixtures by farmers, and intercropping of beans with several other crops, including maize and bananas.

A germplasm improvement strategy involving the CIAT breeding program and African regional and national programs is illustrated in Figure 7. For the foreseeable future most crosses will be made at CIAT, based on information obtained from the nurseries, which have been shipped to Africa. Currently, segregating populations are shipped to Africa from CIAT in the F_4 to F_6 generations as bulks, but from early 1985 an adaptation nursery of early generation progenies from single plant selections made in CIAT in F_2, will be shipped to Africa as an observation nursery. Advanced lines at the VEF stage are being shipped each year, and in the future advanced lines selected in Africa will be returned to the VEF nursery in CIAT. (Third country quarantine arrangements are being made for this shipment with NVRS, Wellesbourne, England.)

A total of 50 international yield trials (IBYAN) are sent to Africa in 1984. Seeds sent from CIAT are being routinely screened in the new seed health laboratory to ensure that they do not contain seed- borne pathogens, and further quarantine is being carried out at Muguga, Kenya.

The total number of breeding materials despatched in 1983 and 1984 is shown in Figure 8. Initially, was the emphasis was to distribute potential parental materials (crossing blocks), and advanced lines, but a significant increase in the number of segregating materials has occurred. Figure 9 , gives two main dates for seed dispatches from CIAT, one in mid-January, and the other in August-September coordinated to the principal seasons for beans in Africa.

The crossing blocks are classified according to projects (Figure 10), and are dispatched by request according to the projects of interest in each area. Crosses between entries in these nurseries may be requested from CIAT according to the results of these nurseries. A number of lines have also been selected by national programs directly from the crossing blocks to enter into national variety testing schemes, notably in Rwanda and Zambia.

The percentage of crosses made at CIAT, which involved cultivars from the principal collaborating countries in Africa, is shown in Figure 20. Since the establishment of the Great Lakes regional program in Rwanda in late 1983, emphasis has been given to crosses with cultivars from Rwanda and Burundi. The collaborative program with the Title XII CRSP in Tanzania has also resulted in a large number of crosses being made in CIAT.

Some of the lines selected from advanced line nurseries to enter national variety testing schemes are shown in Table 68. These include both climbing and bush types from the CIAT breeding program.

Results from the IBYAN trials in 1983 (Figures 11 and 12) show promising results, particularly for A 463, BAT 1387, BAT 1297, A 114, BAT 1671 and A 445.

A number of lines from CIAT have reached advanced stages of testing in certain countries. A climbing bean line, V 79116, is being tested in on-farm trials in Rwanda in 1984. In Zambia BAT 85 and Carioca (introduced from Brazil via CIAT) were the highest yielding in the Zambian Advanced Bean Variety Trial 1983/84, carried out at seven locations, and these may be released as new cultivars. In on-farm trials in the Central province, Carioca was reported to yield 3-4 times as much as local cultivars under all agronomic treatments. In Swaziland, seed multiplication and on-farm trials of A 79, A 86, A 89, A 107, A 179, XAN 66, BAT 1254 and EMP 86, have demonstrated that significant yield increases can be obtained.

The necrotic reaction to BCMV (black root) has been a general problem in lines introduced from CIAT, but many lines have now been identified which do not show either mosaic or black root symptoms to any significant extent (e.g. BAT 1386, BAT 1426, VCA 81007).

Table 68. Advanced lines which entered into national variety testing schemes in Africa, 1984, listed here according to country and location.

RWANDA	BURUNDI	SWAZILAND	ZAMBIA
RUBONA	MOSSO	MALKERNS	MBALA
ACV 83004	ACV 83011	PVMX 1568	PAD 5
ACV 83031	ACV 83031	PVMX 1671	PVA 1288
PVA 711	PAN 29	PVMX 1588	V 83053
PVA 765	PVA 986	PVMX 1652	
PVMX 1591	PVA 1146	PVMX 1673	
V 83050	R 1219	PVMX 1530	
	V 83028	ZAV 83005	
	V 83036	V 83021	
	V 83044	V 83025	
	ZAV 83008	V 83037	
		V 83048	

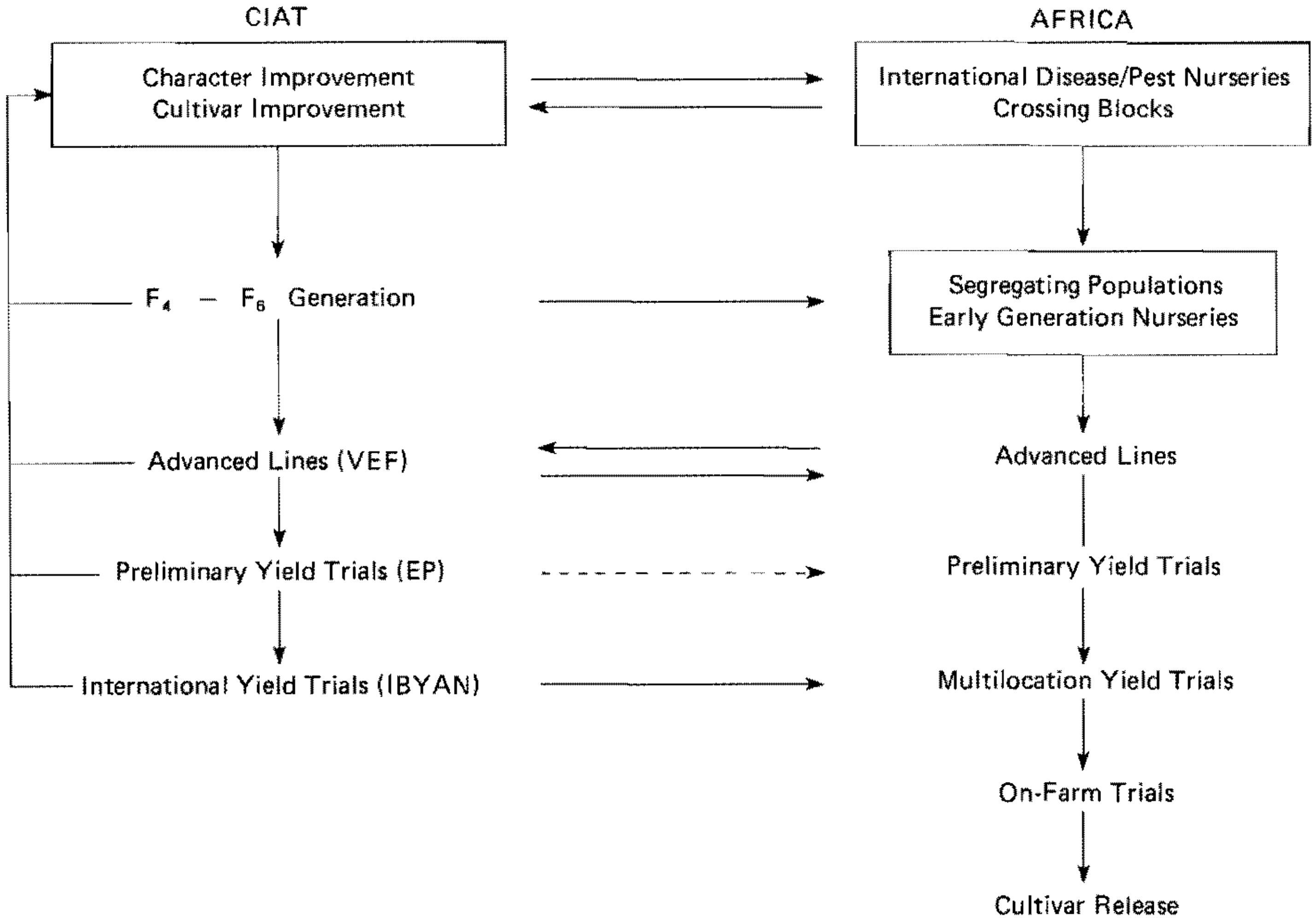


Fig. 7. GERMPLASM IMPROVEMENT STRATEGY FOR AFRICA

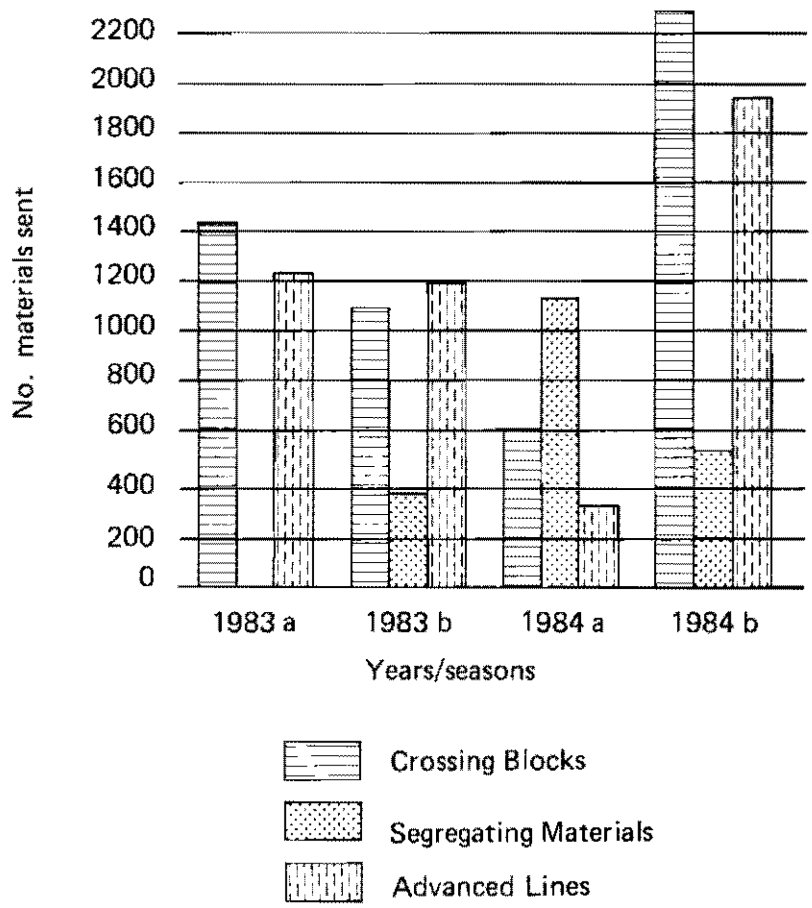


Fig. 8. Breeding materials shipped to Africa during 1983 and 1984.

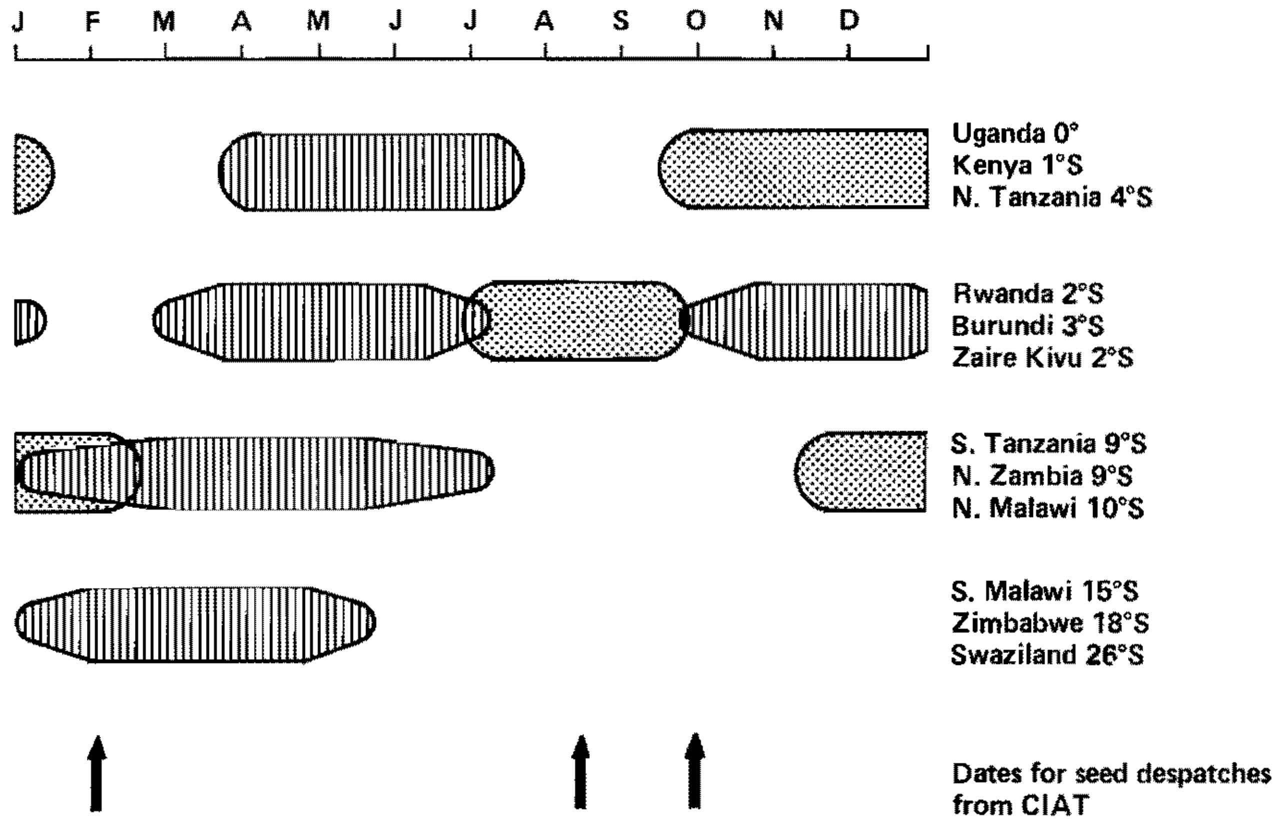
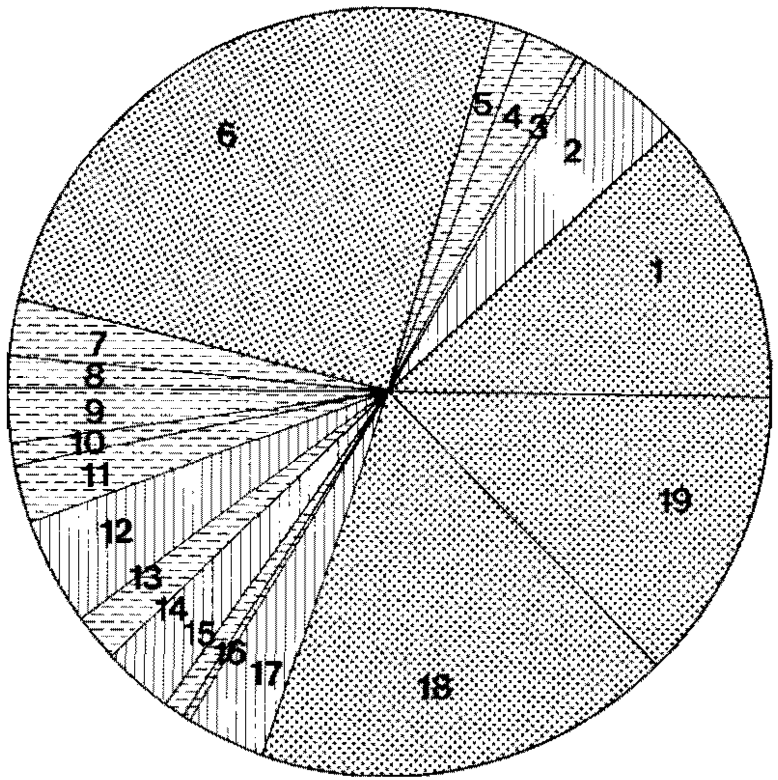


Figure 9. Principal Seasons for beans in Africa.



1	12%	African cultivars
2	5%	Anthracnose resistance
3	1%	Improved architecture
4	2%	Ascochyta resistance
5	1%	Common bacterial blight resistance
6	26%	BCMV resistance
7	2%	Bean fly resistance
8	2%	Bruchid resistance
9	2%	Improved nitrogen fixation
10	1%	Low phosphorus tolerance
11	2%	Photoperiod insensitivity
12	4%	Snap beans
13	2%	Halo blight resistance
14	3%	Angular leaf spot resistance
15	1%	Nematode resistance
16	1%	Rust resistance
17	3%	Drought resistance
18	18%	Andean Region cultivars (cool climate)
19	12%	Andean Region cultivars (warm climate)

Fig. 10. Compositional crossing blocks 1984b (Total = 1,131 lines)

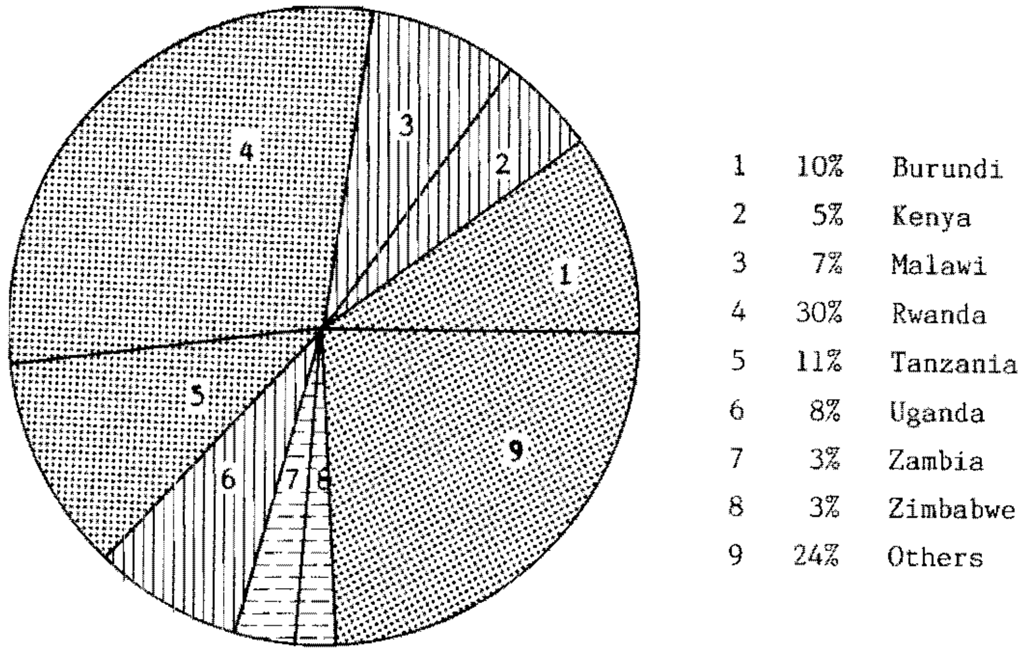


Figure 11. Crosses made for African countries in 1984. A total of 669 crosses wer made and most of theses involved commercial cultivars of the region.

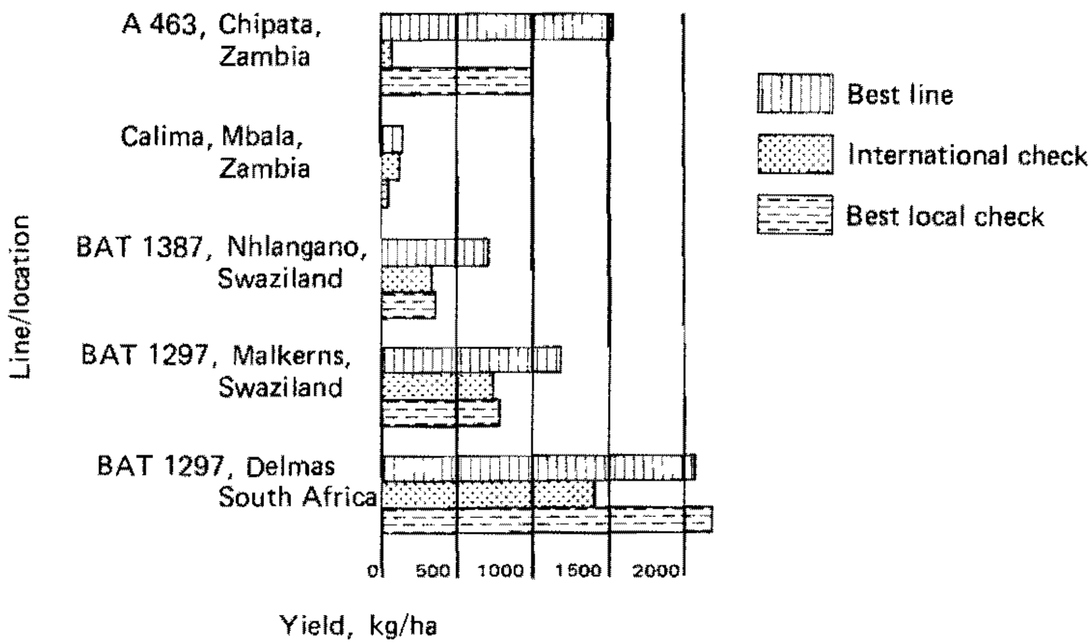


Fig. 12. Results from 1983 IBYAN (group 25) in selected African countries.

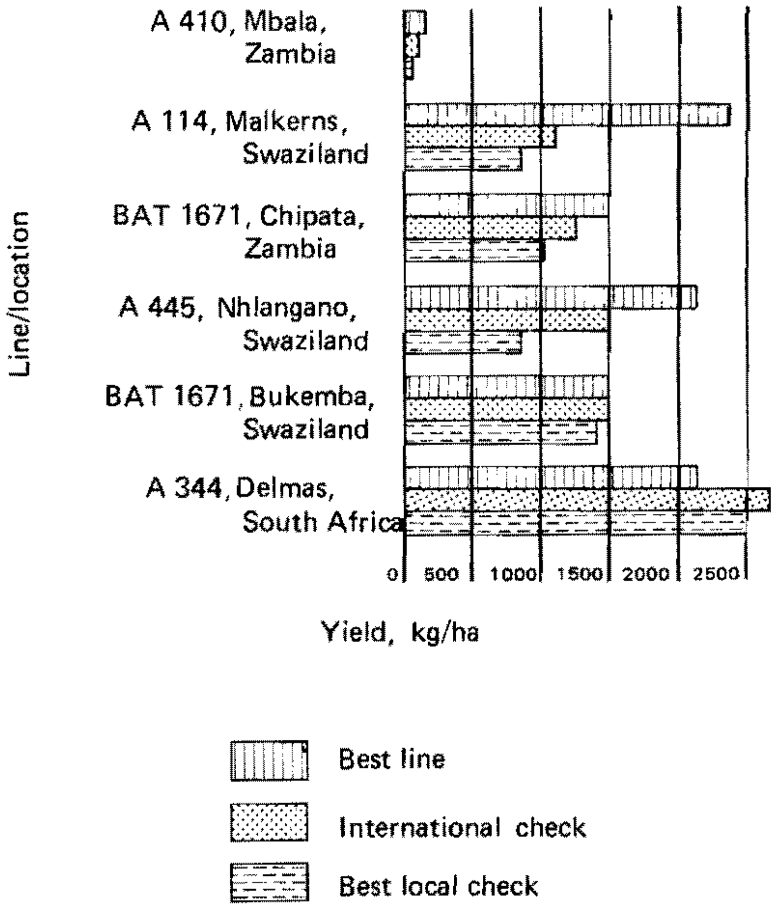


Fig. 13. Results from 1983 IBYAN (group 45) in selected African countries.

h. Andean Region

Collaborative projects continued at the same locations in the Andean Region as described in the 1983 Bean Program Annual Report. All locations received the crossing blocks, for evaluating and selecting parents, F_4 segregating populations, advanced lines (VEF), and IBYAN trials. A total of 547 crosses were made in the Andean Region project in 1984. Of these, 265 crosses involved cultivars from Colombia, 125 from Ecuador, 145 from Peru, and 12 from other areas. In Popayan, 246 crosses were made, mostly in the field, with the objective of breeding improved lines for the highlands (above 1,750 msl.). The remaining 301 crosses were made in the field at Palmira and Santander de Quilichao, with the objective of developing improved material for medium altitudes (1,000-1,750 msl.).

In bush beans the principal objectives of breeding are: to obtain improved plant types including erect type II lines with medium to large seed size (most cultivars, e.g. Calima, are type I); to combine this with resistance to common bacterial blight, rust, angular leaf spot and BCMV for medium altitude climates; to combine this with resistance to halo blight, anthracnose and ascochyta for cool climates. In climbers, the objectives for disease resistance are the same, but the plant type should be suitable for intercropping with maize.

In Colombia, cultivar improvement is carried out in close collaboration with the national program, ICA. The Federacion de Cafeteros and CVC (Corporacion Autonoma Regional del Valle del Cauca) are also involved in conducting regional trials. Advanced lines pass from the breeding programs to the 'Viveros de Apoyo' (Preliminary Nurseries), which are planted in nine locations in medium climate zones, and in five locations in cool climate zones. Approximately 200 lines per year enter this stage of testing, including bush and climbing types.

Out of these nurseries, the best lines are selected for multilocational regional (on-farm) trials. In 1984, these trials consisted of one for bush beans adapted to medium climates, and one for climbers adapted to cool climates.

The most promising of these lines pass on to confirmation trials, prior to variety release. Materials currently at this stage include: BAT 1297, A 36 (bush beans, medium climate); Antioquia 8, Ancash 66, ICA-L33462 (bush beans, cool climate); V 8036, ZAV 83101, ZAV 83102 (climbing beans, medium climate); ICA-La Selva 1, ICA-La Selva 4, ICA-La Selva 7 (climbing beans, cool climate); E 605, ICA-L32980-1-41 (climbing beans, cold climate).

Antioquia 8, ICA-La Selva 1, and E 605 are likely to be released as new cultivars in 1985.

At ICA-La Selva (Rionegro, Antioquia), the collaborative breeding program continues to emphasize climbing beans for relay cropping. The best lines emerging from this program enter the international testing scheme, as well as the national testing scheme organized by ICA. Results of an IBYAN trial containing lines developed at ICA-La Selva demonstrate promising results from breeding at this location (Table 69).

In an advanced yield trial ICA-Llanogrande continued to show its improved yield potential, and a number of new lines significantly outyielded the control (Table 70). However, in trials of advanced breeding lines carried out under reduced soil fertility conditions (Table 71), ICA Llanogrande failed to beat the control cultivar, tending to confirm conclusions from farm trials that this new cultivar will only show its superiority in moderately favorable soils. On the other hand, a number of new lines significantly outyielded both ICA-Llanogrande and ICA-Viboral under these conditions.

Work for the cold highlands continued at ICA-Obonuco (Pasto, Nariño), mostly emphasizing climbing beans for mixed intercropping with maize. Sixty-four advanced lines were identified for testing on farms in 1984. Results of two yield trials of advanced selections at ICA-Obonuco are shown in Table 72, demonstrating significant yield increases compared to the control (Mortiño). The line which has consistently performed best in on-farm trials is E 605 (see section of this report on on-farm research), giving a yield increase of 50% above the control using farmers' practices, and the grain type is highly commercial and readily accepted.

Regional trials of bush beans in Nariño have identified Antioquia 8, ICA L-33462, and BAT 1297 as particularly promising (Table 73). The first of these lines has good resistance to halo blight, a problem in the cool highlands.

Regional trials in the coffee-producing regions of Antioquia, Tolima and Cundinamarca demonstrated an average gain in yield of 18% above the local controls for BAT 1297, with A 36 and PVA 1261 also showing superior results.

One of the most important cropping systems for beans in the Andean region and elsewhere is row intercropping. A new methodology for testing advanced lines in this system has shown useful results in Santander de Quilichao (Figure 14). The trial was planted in four row plots, two rows with maize and two rows without. By harvesting the pairs of rows separately, useful information was gained on the competitive ability of individual lines. For example, PVAD 1407 was the best yielder in the rows without maize, but suffered an almost 50% yield reduction with maize. V 83050, on the other hand, was the top yielder with maize, but yielded relatively poorly without it. ACV 83004 yielded well in both systems.

Another advantage to this methodology is that all growth habits can be tested uniformly in this system.

In Ecuador, E 605 is yielding well in highland areas, confirming its usefulness as a climbing bean for the high Andean region. Additionally, 150 lines were selected in Santa Catalina from segregating materials sent from CIAT, for testing as advanced lines. Nine advanced lines of climbers were selected for inclusion in preliminary yield trials. Six climbing bean materials originally sent from CIAT were included in regional trials, and the best of these at several locations were G 11821, G 11820, and V-3297-6.

Bush beans are grown in the valleys, normally in sole cropping and most early generation selection is being done at Cuenca, but regional trials cover several important areas of the country, including Pimampiro (Imbabura), where the Title XII CRSP project is collaborating with INIAP. At Cuenca, 120 lines were selected from the crossing blocks for inclusion in new crosses. Segregating populations and advanced lines (VEF 1984) were planted. The most promising new materials in regional trials include A 36, PVA 1441 and PVA 1426, introduced originally in the IBYAN.

In Peru, collaborative breeding of climbing beans continued in Cajabamba (department of Cajamarca). From the crossing blocks, 22 lines were selected for use as parents, and one line has been included in on-farm testing- G 10889, a white seeded line from Guatemala, which shows good resistance to ascochyta and anthracnose. Out of a total of 736 segregating populations sent in 1982 and 1983, 12 advanced lines have been identified with superior yield and resistance to the principal diseases. The Line G2829 selected in 1982, was planted in 30 demonstration plots in 1983/84, and farmers were already planting their own fields of the cultivar. It is on sale in the markets at a price 25% less than Caballero (the local cultivar), but is reported to more than compensate in yield, and is achieving consumer acceptance.

Likewise, in the Cuzco area of Peru, progress was made in selecting new parents for halo blight and anthracnose resistance: Montcalm and Mecosta are providing promising offspring of the Red Kidney type. Selections made in the early part of the year in Mollepata (2,800 msl.) were multiplied in Sahuayaco, for planting as advanced lines in the normal growing season in Mollepata. Bush bean lines currently in on-farm testing, introduced via the IBYAN, are W-126 (panamito), BAT 1253, ICA Linea 23, ICA Linea 24.

Climbing beans are grown at a higher altitude than the bush beans in the Cuzco area, and the predominant type is Amarillo Gigante, a large yellow grain-type. Selections from the CIAT VEF nursery planted at Taray (2,960 msl.) included a number of lines with the same grain type as the local cultivar and with improved resistance to anthracnose (e.g. ZAV 83097). Further lines with this grain type were sent from the VEF 1984.

Table 69. Yields (kg/ha) of advanced lines of climbing beans in the IBYAN trial at ICA-La Selva, Rionegro.

Identification	Yield (kg/ha)
VRA 81054	1943
VRA 81066	1609
VRA 81064	1514
Radical (Control)	1140
ICA Viboral (Control)	564
L. S. D. , $p \leq 0.05$	409

Table 70. Advanced lines yield trial, ICA-La Selva. Yield of selected lines planted in relay cropping with maize.

	Yield (kg/ha)	Yield as % control	Seed weight in g/100 seeds	Seed color
ICA Llanogrande	1983	220	50	Cream/purple
ICA La Selva 26	1750	194	61	Cream/red
ZAV 83102	1625	180	62	Cream/red
ICA La Selva 1	1502	167	72	Cream/red
ZAV 83101	1317	146	72	Yellow/red
ICA Viboral (Control)	900	100	58	Cream/red

Table 71. Breeding lines tested in low soil fertility conditions (pH 4.7, 30 kg/ha P_2O_5 added), ICA-La Selva, planted in relay cropping with maize.

Pedigree	Yield (kg/ha)	Yield as % control	Seed color
V-5781-34-32-32-M-M	1652	207	Cream/red
V-5766-37-311-21-M-M	1430	179	Yellow/red
V-5781-34-32-33-M	1419	178	Cream/red
V-5761-35-38-32-M-M	1374	172	Red
ICA La Selva 1	1303	163	Cream/red
ICA La Selva 26	959	120	Cream/red
ICA Viboral (Control)	799	100	Cream/red
ICA Llanogrande	695	87	Cream/purple

Table 72. Results of two yield trials of advanced selections intercropped with maize, ICA-Obonuco, Nariño, Colombia.

	Yield trial 1982		Yield trial 1983		Mean yield
	kg/ha	DAF[a]	kg/ha	DAF	(kg/ha)
E 521	1042 ab*	120	2929 a*	119	1981
E 525	1032 ab	108	2334 ab	117	1683
L-33003-M(4)	631 c	101	2439 ab	102	1535
E 605	1120 a	112	1888 ab	117	1504
L-32980-M(4)	443 cd	98	2513 ab	97	1478
ICA Llanogrande	605 c	110	2190 ab	116	1398
L-32980-M(8)	359 d	96	2182 ab	95	1271
E 166-1	1098 a	117	1373 b	118	1236
Mortiño (Control)	867 b	118	1513 b	126	1190
L-32983	388 d	96	1824 ab	95	1106

[a]DAF = days to flowering

* Yields followed by the same letters are not significantly different at $p \leq 0.05$

Table 73 Results of regional trials of bush beans in Nariño, Colombia (yield in kg/ha).

Entries	Location and altitude (msl)				
	Consaca 1620	La Union 1745	Matituy 1950	Tunjagrande 2200	Mean
Antioquia 8	1707 a*	1093 a*	1356 ab*	1925 a*	1520
BAT 1297	1118 bcd	1151 a	1397 ab	1785 a	1363
ICA L-33462	1066 bcd	885 b	1530 a	2174 a	1414
Calima (control)	1243 bc	1079 a	1163 b	952 cd	1109

* Yields followed by the same letter are not significantly different, p= 0.05.

Table 74. Results of regional trials of bush beans in Cundinamarca (Sasaima), Tolima (Líbano), and Antioquia (Venecia), Colombia, Yield (kg/ha)

Entries	Location and altitude (msl)			
	Sasaima 1200	Libano 1450	Venecia 1650	Mean
BAT 1297	1819	2445	683	1649
A 36	2195	2119	516	1610
PVA 1261	1880	2362	574	1605
Local Control	2440[a]	1498[b]	247[c]	1395

a = Nima

b = Guarzo

c = Cuarentano

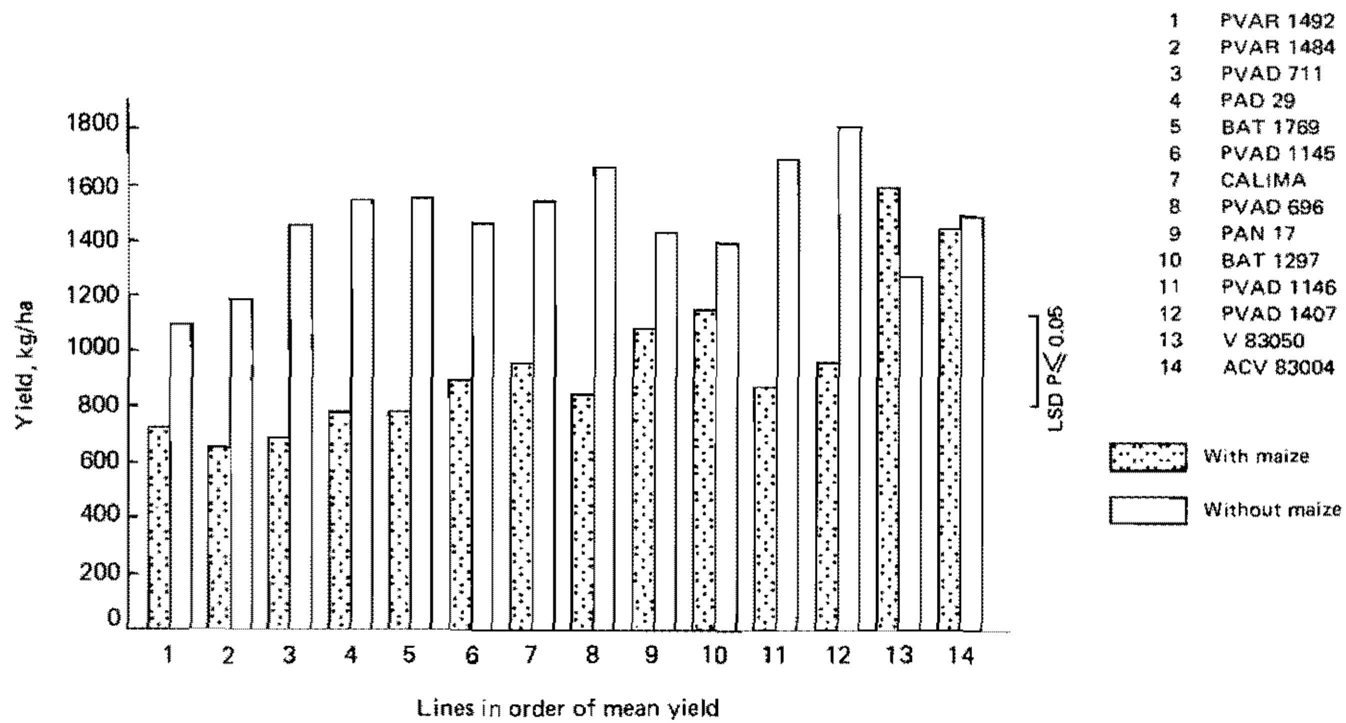


Fig. 14. Yield Trial of Advanced lines intercropped with maize in Santander de Quilichao.

3.3 Evaluation in Uniform Nurseries

The Bean Program uses a three-stage progeny evaluation program identified as VEF, EP and IBYAN.

a. VEF: The bean team nursery (first stage). The bean team nursery VEF/84 contained 1004 entries distributed in 10 groups according to seed color and size, growth habit, and climatic adaptation (Table 75).

The frequency of different growth habits, grain characteristics, and days to flower and to maturity within each group is shown in Tables 76 and 77.

Yield of the top two lines for each growth habit within each group is shown in Table 78.

Reaction to rust and common bacterial blight (Table 79) angular leaf spot (Table 80) and anthracnose (Table 81) are shown for each basic group.

Table 75. Distribution of the 1,004 entries of the VEF/84 over 10 color groups.

Group no.	Growth habit	Seed color	Seed size	Climatic adaptation	No. of entries
10	Bush	black	small	Warm	41
20	Bush	red	small	Warm	124
23	Bush	red-mottled	medium	Warm	71
25	Bush	red-mottled	large	Warm/med	219
30	Bush	white	small	Medium	84
35	Bush	white	med/large	Medium	13
40	Bush	yellow, light tan	med/large	Medium	55
50	Bush	cream, cream striped	small	Warm/med	38
70	Climbing	red	small	Warm	63
85	Climbing	all colors	med/large	Warm/cool	296

Table 76. Number of bean entries in the VEF/84 within each group according to growth habit, and phenological characteristics.

Group no.	Growth habit I	II	III	IV	Days to flowering 45	45-50	50	75	75-90	Physio logical maturity 90
10	-	24	7	-	6	34	1	1	38	2
20	4	80	39	-	37	83	4	11	112	1
23	36	32	4	-	124	-	-	124	-	-
25	186	9	20	-	170	48	1	20	184	15
30	2	57	25	-	4	74	6	-	80	4
35	7	2	5	-	8	5	-	3	9	1
40	36	3	8	2	35	11	6	4	44	1
50	2	17	19	-	3	35	-	12	26	-
70	-	-	1	62	1	43	19	-	27	35
85	-	-	-	299						

Table 77. Number of bean entries in the VEF/84 within each group according to seed characteristics.

Group no.	Brilliance Shiny	Opaque	Seed size (g/100 seeds) 25 Small	25-40 Medium	40 Large
10	2	39	31	10	
20	102	22	82	42	
23	66	6	9	36	27
25	203	16	1	58	160
30	40	44	84		
35	9	4		13	
40	49	6	7	45	
50	7	31	28	9	1
70	61	2		62	1
85	262	34			

Table 78. Yield (kg/ha) of the top two lines in the 1984 VEF within each group.

Group	Line	Yield
10	CUBA-CUETO-25-9-N	5086
10	NAG 38	5058
20	RAO 34	5176
20	RAB 56	4817
23	PAI 6	4884
23	PAI 117	4682
25	ZAV 84084	4766
25	PAI 39	4088
30	PAN 38	5206
30	ZAV 8339	4613
35	BLM 8	4343
	BLM 9	4139
40	BAN 30	3922
	MITA -1-4M-99	3602
50	DOR 350	4010
	EMP 89	3936
70	ACV 84018	5989
	ACV 84030	5328
85	ZAV 84127	7840
	ZAV 84130	7651

Table 79. Number and proportion of bean entries in each basic group of VEF/84 according to their reaction to rust and common bacterial blight of beans.

Group	Number of entries	Rust			CBB		
		R[a]	I	S	R	I	S
10	41	13	12	16	1	4	36
20	124	24	37	63	3	33	88
25	219	187	31	1	17	102	100
30	84	32	31	21	0	16	68
35	13	4	6	3	0	1	12
40	53	38	13	2	0	6	47
50	38	11	17	10	0	2	36
70	63	46	16	1	0	8	55
85	296	147	139	10	9	239	48
TOTAL	931	502	302	127	30	411	490

[a] R = resistant

I = intermediate

S = susceptible

Table 80. Number of bean entries in each basic group of the VEF/84 according to their angular leaf spot (ALS) reaction.

Group	Resistant	Intermediate	Susceptible	Total
10	0	29	9	38
20	0	69	55	124
25	1	159	59	219
30	7	75	2	84
35	1	11	0	12
40	5	45	2	52
50	2	28	8	38
70	0	57	6	63
85	3	281	12	296
	19	754	153	930

Table 81. Number of bean entries in each basic group of the VEF/84 according to their anthracnose reaction.

Group	Resistant	Intermediate	Susceptible	Total
10	2	16	20	38
20	6	40	75	121
25	54	92	63	209
30	1	25	56	82
35	-	7	5	12
40	1	13	28	42
50	8	19	11	38
70	58	5	-	63
85	250	38	2	290
	380	255	257	895

b. EP (Preliminary Yield Trial), second stage. The first semester EP was evaluated between March and July 1984 in Palmira and Popayan and consisted of 446 entries and 38 controls (Tables 82 and 83). The entries and their controls were distributed in 14 groups according to size, seed color and growth habit whether bush beans or climbing. Each group was planted in random blocks with three replications under high input conditions in Palmira and Popayan, respectively (Table 83).

Black, small-seeded (Group 10). In small-seeded black beans the differences in yields among varieties were highly significant in Palmira and Popayan.

In Table 84, the average yield of the advanced lines of small-seeded black beans was 2,026 kg/ha for Palmira and 2,505 kg/ha for Popayan. In Palmira, there were significant differences between the majority of the lines which produced above-average yields and the average of the controls (Ica Pijao, BAT 527 and BAT 271), the exceptions being NAG 43, NAG 71 and NAG 86. In Popayan, there were no significant differences between the lines which produced above-average yields and the average of the controls with the exception of NAG 28 (Table 84).

Of the 62 entries of small-seeded black beans, 12 (19.3%) had yields which were above-average in the two locations. They are: RAB 143, RIZ 13, PVMX 1656, PVMX 1659, NAG 16, PVMX 1682, NAG 28, NAG 85, PVMX 1660, DOR 312, XAN 147, NAG 86.

Red, small-seeded (Group 20). In the experimental lines of the small-seeded red beans the yield differences were highly significant in the two locations.

The average yield for the group was 1,947 kg/ha for Palmira and 2,556 kg/ha for Popayan (Table 85). In Palmira, there was a significant difference between the lines which produced above-average yields and the average of the controls (A 21, Zamorano 2 and BAT 795) In Popayan, there were no significant differences for the majority of the lines which produced above-average yields with the exception of RAB 95 and RAB 92.

Of the 62 advanced lines of small red beans, 12 (19.3%) had yields which were above-average in the Palmira and Popayan environments. There are: RAB 95, RAB 141, RAB 2, RAB 68, RAB 73, RAB 128, DOR 308, RAB 93, RAB 92, RAB 101, RAB 154, and XAN 155.

Red-mottled, medium and large-seeded (Group 25). In this group the yield differences were highly significant in both locations.

In Table 86, the average yield of the group for Palmira was 1,860 kg/ha and 2,015 kg/ha for Popayan. Diacol Calima, Linea 24 and BAT 1297 were used as checks.

Of the 155 lines which constitute the group, 22 (14.1%) were common to both locations with above-average yields. They are: PVAD 262, PAI 77, PAI 46, PVAD 1435, PAI 9, PVAD 1438, PAI 12, PAD 28, PAI

103, PVAD 1216, PAI 98, PVAD 1374, PVAD 352, PVAD 1345, PAI 37, PAI 14, PAI 96, PAI 105, PVAD 773, PAI 97, PVAD 1198, and PAI 36.

White, small-seeded (Group 30). In Palmira and Popayan the yield differences were highly significant. The average yield of the group was 1,807 kg/ha in Palmira and 1,732 kg/ha in Popayan. In the Palmira environment, the lines in the group presented significant differences in above-average yield and the average yield of the controls (78-0374, Ex Rico 23 and BAT 1061) (Table 87).

Of the 32 lines which constitute the group, one line or 3% produced above average yields in both environments. This was PAN 19.

White, medium and large-seeded (Group 35). The advanced lines of medium and large-seeded white beans presented highly significant differences in yields in both locations.

In Palmira, the average yield of the group was 1,484 kg/ha and 1,261 kg/ha for Popayan. There was no significant difference in the yields of the lines which produced above-average yields and the average of the controls, Table 88 .

Of the 12 lines in the group, four of them or 33% produced above-average yields in the two locations. They are: PVAR 1476, PVAR 1501, WAF 2, and WAF 1.

Cream yellow, medium and large-seeded (Group 40). In this group of advanced lines of cream colored, yellow and light brown medium and large-seeded beans from the southern Pacific coast, the differences in yields were highly significant in Palmira and Popayan.

In Palmira, the average yield of the group was 1,617 kg/ha and in Popayan, it was 2,085 kg/ha. There were significant differences in yields in all the lines and in both environments when the above average yield of each line was compared with the average yield of the controls (Canario 107, Bayo Titan and A 197) (Table 89).

Of the 29 accessions which constitute the group, eight were common to both locations and yielded above-average. They are: EMP 138, BAT 1771, EMP 135, XAN 136, RIZ 29, BAN 29, BAN 14 and DOR 307.

Mexican altiplano (Group 45). In beans for the Mexican highlands (cream, coffee-colored, light solid colors, mottled and striped, medium and big-seeded) there were highly significant differences in yields in the two environments. The average yield of the group was 1,793 kg/ha for Palmira and 2,469 kg/ha in Popayan. There were significant differences in the Palmira environment when the above-average yields of the group were compared and the average yield of the controls (A 114, G 2858, Ojo de Cabra and 997-CH-73) (Table 90).

Of the 13 lines which constitute the group, five (38.4%) produced above-average yields in both locations. They are: MAM 4, MAM 12, MAM 8 and MAM 11.

Cream, small-seeded (Group 50). The EP of the small and medium-sized cream-colored beans from Brazil showed highly significant differences in yields in Palmira and Popayan. In Palmira, the group gave an average yield of 1,616 kg/ha and 2,446 kg/ha in Popayan (Table 91).

Of the 19 lines evaluated, two (10.5%) produced above-average yields for the two sites. They are: FEB 2 and FEB 13. Two brazilian varieties and two CIAT promising beans were used as checks A 286, IPA 7419, Carioca and BAT 477.

With the exception of the small, medium and large-seeded white beans which produced better yields in Palmira, in the other groups higher yields were achieved under the environmental conditions of Popayan (Tables 84 to 91) under the high input treatment. This partially eyplains the fact of better adaptation of materials to the Popayan environment, and pod set in the Palmira environment.

The highest yielding group of beans in Palmira were the small-seeded blacks (2,026 kg/ha, average) and the lowest yielding ones were the large-seeded whites (1,484 kg/ha, average). In Popayan, the groups with the highest average yield were the small reds (2,556 kg/ha) and the small blacks (2,505 kg/ha) and those with the lowest yield were the large-seeded whites (1,261 kg/ha).

In, part, the low yields of the medium and large-seeded white beans can be attributed to a low percentage of germination.

Climbing beans (Groups 60, 70, 80, and 85). Table 92 gives the above-average yields for the experimental lines of bush beans in these groups achieved under high input conditions in association with maize H-211 in the Palmira and Popayan environments.

In group 60, the small-seeded black beans from the tropics, the average yield was 1,049 kg/ha in Palmira and 689 kg/ha in Popayan. There were no significant differences between lines which yielded above-average and the average of the controls (V8025, V8017, G 6040). Lines V-8368 and V-8367 had the highest yields of this group.

The small-seeded red bush beans yielded an average of 1,009 kg/ha in Palmira and 793 kg/ha in Popayan.

The line ACV-8312 produced above-average yields in both locations.

The average yields in both environments for Rojo 70, Rojo de seda and compuesto Alajuela used as climbing beans of different colors for the tropics were 1,089 kg/ha and 777 kg/ha for Palmira and Popayan, respectively. Lines common to both environments which yielded above-average were: ZAV-8314, ZAV-8303, V-8328, ZAV-8341, ZAV-8306, V-8309, ZAV-8313. Amapola del Camino, P 589 and P 364 were the three entries used as checks.

The group 85, of bush beans of different colors and for cold climate environments, yielded an average of 456 kg/ha in Popayan.

There were no significant differences between the lines which produced above-average yields, and the average of the controls. (ICA Viboral, ICA Llanogrande and Radical).

In general, the bush beans evaluated in groups 60, 70 and 80 planted in association with maize had higher yields in the Palmira environment.

The EP nursery was evaluated under field conditions for the disease reaction to the most important bean pathogens. The evaluations were conducted in Palmira for rust and bacterial blight and in Popayan for anthracnosis, angular leaf spot and Ascochyta.

Table 93 shows the reaction of the EP entries by group to anthracnosis and Table 94 to angular leaf spot. (ALS). Lines with either intermediate or resistant reaction to both were selected for further evaluation (Table 95). These accessions were planted in Popayan in the second semester of 1984 and inoculated sequentially with both the ALS and anthracnosis pathogens.

The rust and bacterial blight evaluations for the 1984 EP are shown in Table 96. A list of the most resistant entries from the 1984 VEF and EP nurseries to both rust and common bacterial blight is shown in Table 97.

Table 82. Number of bean entries in the 1984 EP within each basic group according to growth habit and phenological characteristics.

Group	Growth habit				Days to flowering			Days to physiological maturity			Brilliance		Seed size (grs/100 seeds)		
	I	II	III	IV	45	45-50	50	75	75-90	90	Shiny	Opaque	Small 25	Medium 25-40	Large 40
10	-	52	10	-	62	-	-	61	1	-	9	53	52	10	-
20	-	44	18	-	62	-	-	61	1	-	53	9	54	8	-
25	96	26	33	-	155	-	-	148	7	-	138	17	36	63	56
30	-	12	20	-	32	-	-	32	-	-	11	21	32	-	-
35	9	-	3	-	12	-	-	12	-	-	7	5	1	11	-
40	6	13	10	-	29	-	-	29	-	-	16	13	29	-	-
45	-	2	11	-	13	-	-	13	-	-	8	5	4	9	-
50	-	3	16	-	19	-	-	16	3	-	6	13	12	7	-
60	-	-	-	5							-	5	5	-	-
70	-	-	-	24							22	2	19	5	-
80	-	-	-	33							26	7	17	16	-
85	-	-	-	15							16	2	-	-	-

Table 83. EP trials distributed in 14 groups according to size, seed color, and growth habit, 1984.

Group no.	Growth habit	Color	Size	Climatic or geographic situation	No. of entries per semester: Palmira	Control	Popayan	Control
10	Bush	Black	Small	Warm	62	3	62	3
20	Bush	Red	Small	Warm	62	3	62	3
25	Bush	Red, red mottled	Med./large	Warm o medium	155	3	155	3
30	Bush	White	Small	Medium	32	3	32	3
35	Bush	White	Med./large	Medium	12	3	12	3
40	Bush	Cream, yellow, light brown	Med./large	Southern Pacific Coast	29	3	29	3
45	Bush	Cream, light brown, pale, mottled	Med./large	México: dry and humid temperate zones	13	4	13	4
50	Bush	Cream	Small/med.	Brasil	19	4	19	4
60	Climbing	Black	Small	Warm climate	5	3	5	3
65	Climbing	Black	Small	Cool climate	–	–	–	–
70	Climbing	Red	Small	Warm	24	3	24	3
80	Climbing	Diverse colors		Warm	33	3	33	3
85	Climbing	Diverse colors		Cool	–	–	15	3

Table 84. Outstanding experimental lines of bush beans with above-average yields (kg/ha) under high input conditions in the EP 84A for small black seeded beans in Palmira and Popayan.

Line	Palmira	Popayan
L-80-2	2486 +[b]	3014 NS[a]
RIZ 13	2409 +	3048 NS
NAG 16	2258 +	3130 NS
PVMX 1682	2214 +	3424 NS
NAG 28	2202 +	3534 +
PVMX 1660	2171 +	2905 NS
DOR 312	2169 +	2979 NS
$\bar{X}$ of group (n=195)	2026	2505
$\bar{X}$ of controls (n=3)	1899	2835
DMS (5%)	237.26	687.51
C.V. (%)	12	23

[a] NS : non-significant

[b] + : Significant with respect to average of the controls

Table 85 . Experimental lines of bush beans with above-average yields (kg/ha) under high input conditions in the EP 84A for small-seeded red beans in Palmira and Popayan.

Lines	Palmira	Popayan
RAB 95	2606 +[a]	3605 +
RAB 141	2382 +	2790 NS[b]
RAB 73	2178 +	3253 NS
RAB 128	2161 +	3021 NS
RAB 93	2074 +	2998 NS
RAB 92	2045 +	3554 +
RAB 154	2027 +	3038 NS
$\bar{X}$ of group (n=195)	1947	2556
$\bar{X}$ of controls (n=3)	1655	2670
No. of lines	195	195
+ DMS (5%)	222.14	706.24
C.V. (%)	12	21

[a]+ : Significant with respect to average of controls
[b]NS : Non-significant

Table 86. Experimental bush bean lines with above-average yields (kg/ha) under high input conditions in the EP 84A for red, red-mottled, medium and large-sized seeds in Palmira and Popayan.

Line	Palmira	Popayan
PVAD 262	2508 +[a]	2285 NS
PAI 77	2281 +	2694 +
PAI 46	2260 +	2526 +
PVAD 1435	2223 +	2213 NS
PAI 9	2179 +	2249 NS
PVAD 1438	2172 +	2591 +
PAI 12	2161 NS[b]	2443 +
PAD 28	2142 NS	2227 NS
PAI 103	2123 NS	3117 +
PAI 98	2096 NS	2779 +
$\overline{X}$ of group (n=474)	1860	2015
$\overline{X}$ of controls (n=3)	1979	1923
+ DMS (5%)	193.27	520.18
C.V. (%)	14	29

[a] + = Significant with respect to average of the controls.
NS: Non-significant

Table 87 . Outstanding experimental bean lines with above-average yields (kg/ha) under high input conditions in the EP 84A for small-seeded white beans in Palmira and Popayan.

Line	Palmira	Line	Popayan
XAN 135	2147 +[a]	RIZ 19	2754 +
BAT 1713	2080 +	PAN 7	2641 +
PAN 21	2042 +	BAT 1717	2296 +
PAN 12	2024 +	EMP 125	2275 +
BAT 1712	2020 +	BAT 1714	2252 +
PAN 34	1955 +	BAT 1678	2249 +
EMP 131	1947 +	EMP 133	2210 +
PAN 27	1937 +	PAN 18	2207 +
PAN 19	1910 +	PAN 19	2188 +
$\bar{X}$ of group	1807		1732
$\bar{X}$ of controls (n=3)	1629		1599
No. of lines	105		78
DMS	141.62		537.19
C.V. (%)	9		30

[a] + : Significant with respect to average of controls.
NS: Non-significant

Table 88. Outstanding experimental lines of bush beans with above-average yields (kg/ha) under high input conditions in the EP 84A for medium and large white beans in Palmira and Popayan.

Line	Palmira	Line	Popayan
PVAR 1476	1681 NS[a]	WAF 1	2162 +
WAF 3	1675 NS	WAF 2	2049 NS
PVAR 1501	1636 NS	PVAR 1476	1717 NS
WAF 7	1613 NS	PVAR 1501	1322 NS
WAF 2	1566 NS		
WAF 1	1508 NS		
WAF 6	1501 NS		
$\overline{X}$ of group (n=45)	1484		1261
$\overline{X}$ of controls (n=3)	1606		1548
+ DMS (5%)	193.40		560.45
C.V. (%)	13		39

[a] + : Significant with respect to average of controls
NS : Non-significant

Table 89. Outstanding experimental lines of bush beans with above-average yields (kg/ha) under high input conditions in the EP 84A for cream, yellow, light brown, medium and big-seeded beans in Palmira and Popayan.

Line	Palmira	Popayan
EMP 138	2174 +[a]	2523 +
BAT 1771	2029 +	2391 +
EMP 135	1850 +	2260 +
XAN 136	1843 +	2681 +
RIZ 29	1843 +	2338 +
BAN 9	1812 +	3501 +
BAN 14	1810 +	2799 +
X of group (n=96)	1617	2085
X of controls (n=3)	1343	1385
DMS (5%)	183.15	715.07
C.V. (%)	20	32

a + : Significant with respect to average of controles
NS : Non-significant

Table 90. Outstanding experimental lines of bush beans with above-average yields (kg/ha) under high input conditions in the EP 84A for cream, brown, light colored solids, mottled and striped beans of medium and large seed sizes in Palmira and Popayan.

Line	Palmira	Line	Popayan
MAM 10	2461 +[a]	MAM 8	3110 NS
		MAM 1	2978 NS
MAM 4	2134 +	MAM 11	2919 NS
		MAM 2	2895 NS
MAM 12	2094 +	MAM 12	2833 NS
MAM 2	1959 +	MAM 9	2761 NS
MAM 8	1955 +	MAM 4	2637 NS
MAM 11	1922 +		
$\bar{x}$ of group	1793		2469
$\bar{x}$ of controls (n=4)	1706		2993
No. of lines	51		48
DMS (5%)	151.09		
C. V. (%)	19		24

[a] + : Significant with respect to average of controles
NS : Non-significant

Table 91. Outstanding experimental lines of bush beans with above-average yields (kg/ha) under high input conditions in the EP 84A for small and medium-sized cream colored beans in Palmira and Popayan.

Line	Palmira	Line	Popayan
FEB 14	2130 +[a]	FEB 19	3449 +
FEB 18	2054 +	FEB 12	3038 NS
FEB 2	2048 +	FEB 17	2939 NS
FEB 4	2038 +	FEB 2	2894 NS
FEB 15	2007 +	FEB 1	2754 NS
FEB 10	1833 NS	FEB 18	2716 NS
FEB 13	1733 NS	FEB 8	2655 NS
FEB 3	1726 NS	FEB 6	2632 NS
		FEB 13	2585 NS
$\bar{X}$ of group (n=69)	1616		2446
$\bar{X}$ of controls (n=4)	1752		2655
DMS (5%)	162.56		660.98
C.V. (%)	20		22

[a] + : Significant with respect to average of controls.
NS : Non-significant

Table 92. Outstanding experimental lines of climbing beans from groups 60,70,80, and 85 with above-average yields (kg/ha) with high inputs in Palmira and Popayan from the EP 84A.

	Palmira		Popayan
Group 60 Small-seeded blacks for the tropics			
		Line	
V 8368	1113 NS[a]	V 8359	838 NS
V 8367	1107 NS	V 8364	752 NS
$\bar{X}$ of group (n=24)	1049		689
$\bar{X}$ of controls (n=3)	1082		829
+ DMS (5%)	324.87		234.31
C.V. (%)	19		20
Group 70 Small-seeded red beans for the tropics			
Line		Line	
ACV 8323	1309 +	ACV 8324	1060 +
ACV 8310	1260 NS	ACV 8312	1043 +
ACV 8331	1247 NS	ACV 8316	916 NS
ACV 8351	1236 NS	ACV 8329	900 NS
ACV 8321	1206 NS	ACV 8365	880 NS
ACV 8312	1112 NS	ACV 8342	880 NS
ACV 8311	1102 NS	ACV 8349	863 NS
		ACV 8340	844 NS
$\bar{X}$ of group (n=81)	1009		793
$\bar{X}$ of controls (n=3)	979		721
+ DMS (5%)	288.57		268.66
C. V. (%)	20		24

(Continued)

[a] + : Significant with respect to average of controls.
NS : Non-significant

Table 92. (Continued)

	Palmira	Popayan
Group 80 Diverse colors for the tropics		
Line		
ZAV 8314	1436 +[a]	943 +
V 8328	1248 +	922 NS
ZAV 8341	1193 NS	991 +
ZAV 8306	1136 NS	995 +
V 8309	1125 NS	1122 +
ZAV 8313	1124 NS	896 NS
$\overline{X}$ of group (n=108)	1089	777
$\overline{X}$ of controls (n=3)	1004	677
DMS (5%)	211.50	258.01
C.V. (%)	14	24
Group 85 Diverse colores for cold climate		
Line		
ICA La Selva 2	680 NS	
ICA La Selva 8	677 NS	
ICA La Selva 1	607 NS	
ZAV 8373	606 NS	
ZAV 8393	544 NS	
ZAV 8392	507 NS	
$\overline{X}$ grupo (n=45)		456
$\overline{X}$ of control (n=3)		615
+ DMS (5%)		182.68 26

[a] + : Significant with respect to average of controls.
NS : non-significant

Table 93. Number of bean entries in each basic group of the EP 84 according to their anthracnose reaction.

Group	Resistant	Intermediate	Susceptible
10	7	14	41
20	3	8	51
25	9	69	77
30	0	2	29
35	1	2	9
40	1	6	21
45	6	5	2
50	3	15	1
60	0	5	0
70	16	6	2
80	21	10	2
85	10	4	1
	77	146	236

Table 94. Number of bean entries in each basic group of the EP 84 according to their angular leaf spot (ALS) reaction.

Group	Resistant	Intermediate	Susceptible
10	6	31	24
20		40	21
25	1	83	70
30	1	18	12
35	1	9	1
40	6	17	6
45		2	11
50		14	5
60	2	3	
70		19	5
80		22	11
85	1	14	
	18	272	166

Table 95. Lines from the EP 84 with either intermediate or resistant reaction to both anthracnose (ANT) and angular leaf spot (ALS) of beans and their *Ascochyta* (ASCO) reaction in the field in Popayan.

Group	Identification	ANT	ALS	ASCO.
25	PAD1	3.0/1.5	2.5/2.5	4.5
25	PVAD 508	1.5/1.0	3.0/2.5	4.0
25	PVAD 781	2.5/1.5	2.5/2.5	3.5
25	PVAD 773	2.0/2.5	3.0/2.5	4.0
25	PVAD 561	2.5/1.5	3.0/2.5	4.0
25	PVAD 1261	2.0/1/5	3.0/2.0	4.0
25	DOR 303	2.5/1/5	2.5/2.0	4.0
25	PVAD 434	2.0/1.5	2.5/2.0	4.5
25	PVAD 1312	2.5/2.0	2.5/2.0	4.5
35	BLM 3	2.0/1.5	3.0/2.5	4.5
35	BAT 1769	2.0/1.0	3.0/2.0	4.0
40	EMP 127	3.0/2.0	3.0/2.5	3.5
45	MAM 1	2.5/1.5	3.0/2.0	3.5
50	FEB 9	2.5/1.5	3.0/2.0	3.5
50	FEB 17	2.0/2.5	3.0/2.5	3.5
50	FEB 16	2.0/1.5	3.0/2.5	3.5
50	FEB 8	2.0/2/5	2/5/2.0	4.0
60	V 83060	3.0/2.5	3.0/2.5	3.5
70	ACV 83051	2.5/2.5	3.0/2.5	3.5
70	ACV 83016	2.0/1.0	3.0/2.5	3.5
70	ACV 83021	1.5/1.0	2.5/2.0	4.0
70	ACV 83039	2.0/1.5	2.5/2.5	3.5
80	V 83037	1.5/2.0	3.0/2.5	3.5
80	V 83039	2.5/1.5	3.0/2.5	4.0
80	V 83028	1.5/1.0	2.5/1.5	3.0
80	V 83007	2.0/1.5	2.5/2.5	3.5
80	ZAV 83009	2.0/1.0	3.0/2.5	3.5
80	ZAV 83032	1.5/1.5	2.5/1.0	3.5
80	ZAV 83058	1.5/1.5	3.0/2.5	3.5
80	V 83042	2.0/2.5	3.0/2.5	3.5
85	ZAV 83071	1.0/1.0	2.5/1.0	3.0
85	ZAV 83092	1.5/1.0	2.5/1.0	3.5
85	ZAV 83093	2.0/1.0	2.5/2.5	3.5
85	ZAV 83094	1.0/1.0	2.5/1.5	3.5
85	ZAV 83095	2.5/1.0	2.5/1.0	3.5
85	ZAV 83090	1.0/1.0	2.5/1.0	3.5
85	ZAB 83073	1.0/1.0	3.0/1.0	3.0
85	ZAV 83076	2.0/1.0	3.0/1.0	3.5
85	ZAV 83098	2.0/1.5	3.0/1.0	3.5
85	ICA La Selva 2	3.0/1.0	3.0/1.0	3.5
85	ICA La Selva 8	1.5/1.0	3.0/2.0	3.0
85	ICA Viboral	1.5/1.0	2.5/1.0	3.5
85	ICA Llanogrande	2.5/2.0	2.5/1.0	3.5
85	Radical	1.5/1.0	3.0/1.0	3.5

Table 96. Number and proportion of bean entries in each basic group of the EP 84 according to their reaction to rust and common bacterial blight (CBB) of beans.

Group	Number of entries	Rust			CBB		
		R[a]	I	S	R	I	S
10	62	40	13	9	2	34	26
20	62	18	16	28	9	27	26
25	155	46	66	43	26	46	83
30	32	12	1	19	0	19	13
35	12	4	6	2	1	8	3
40	29	14	6	9	2	8	19
45	13	2	5	6	0	4	9
50	19	5	3	11	0	3	16
60	5	2	2	1	0	0	5
70	24	13	7	4	0	4	20
80	33	12	7	14	0	5	28
85	15	5	8	2	0	1	14
TOTAL	461	173	140	148	40	159	262

[a] R = Resistant

I = Intermediate

S = Susceptible

Table 97. The most resistant entries from the 1984 VEF and EP nurseries to both rust and common bacterial blight of beans.

Group	Entries
10	NAG 37, DOR 310
20	RAB 101, RAB 128, RAB 211
25	TH 88-36-C1,TH 88-36-C2, VCAM-101-C4, SCBZ-121-C2, VCBZ-131-C1, VCMX-159-C2,VCMZ-163-C5, ICA-267-2-C2, ICA-269-1-C3,ICA-269-1-C5, ICA-271-1-C4, PVAD-172-A, PVAD-386, PVAD-473, PVAD-643, PVAD-696, PVAD-702 PVAD-781, PVAD-916, PVAD-1022, PVAD-1122, PVAD-1216, PVAD-1258, PVAD-1438.
40	BAT 1769, DOR 307, EMP 127, EMP 129, EMP 135.
85	TIB-30-41, B-5778-32-31-21, B-5778-322-34-21, V-5778-322-34-21, B-5778-342-32-32, V-5781-34-32-33.

c. IBYAN: International Bean Yield and Adaptation Nursery (third stage).

IBYAN 1983. During 1984, CIAT distributed 279 bush and 31 climbing IBYAN trials. Results of these trials are published in a separate report. Tables 98-103 show the outstanding lines by color groups.

BAT 1432 and XAN 87 were among the black-seeded lines that most frequently figured as top performers (Table 98). In the red-seeded group, BAT 1493 and BAT 1289 were the outstanding lines (Table 99). BAT 1297 and A 463 were most frequently among the best red-mottled materials (Table 100). A 321 and A 292 were the best cream-seeded lines. In the group of materials developed for the Mexican highlands, A 445, BAT 1671, A 114, Carioca and 997-CH-73 (a line developed by Mexico) were the outstanding lines (Table 101). A 321 and A 292 were the best cream-seeded lines (Table 102), while A 445 was most frequently outstanding in the cream-striped (Carioca) seed group (Table 103).

IBYAN 1984. The 10 nurseries which compose the IBYAN/84 contained a total of 77 bush bean and 31 climbing bean lines. The present report only includes results from the IBYAN trials planted by the Bean Program in Colombia in the first semester of 1984 (Tables 104-110).

The materials developed for the Mexican highlands were the ones that showed the highest yield at Palmira (1000 msl). A 321 yielded almost 4000 kg/ha (Table 108). The best small black and red-seeded lines yielded 3000 kg/ha (Tables 104,105), whereas the best medium and large-sized red mottled beans showed yields in the range of 2300 and 2500 kg/ha (Tables 106, 107).

In Popayan (1800 msl) the yields were higher than in Palmira. The best cream-seeded materials PVBZ 1896 and PVBZ 1876 yielded over 4000 kg/ha (Table 109). The best black-seeded line yielded 3800 kg/ha (Table 104) and of both the small, red-seeded and large, red-mottled beans, the best lines yielded around 3500 kg/ha (Table 99 and 100). The best medium sized red-mottled beans yielded slightly over 3000 kg/ha (Table 106).

MCD257, a medium-sized, red-mottled bean (developed in the BCMV-color linkage study) was the only line that had an outstanding performance both at Palmira and Popayan (Table 107). In Popayan line PV 1258, outperformed BAT 1297, the outstanding line in a large number of trials in Colombian sites (Table 106). BAT 271, continued to show a consistent performance at Palmira where it has proved to be the best line available (Table 104). Carioca, once again confirmed that it is one of the best lines available for the cream-seeded group both at Palmira and Popayan (Table 109).

In the climbing bean trial for cool climates, the three outstanding lines proved to be as good as the best local material available, including the newly released variety ICA-Llanogrande and the line ICA La Selva 8 (Table 110).

Table 98. Yield (kg/ha) of the top two lines for each of the 17 sites where the black-seeded entries were tested, IBYAN/83.

Location		Line	Yield	Line	Yield	LSD_{05}
Villa Ahumada	HON	XAN 112	2979	BAT 1481	2979	683
Arist. del Valle	ARG	Tamazulapa	1170	BAT 1467	985	579
San José	CRI	A 237	1618	Tamazulapa	1562	392
Catacamas	HON	XAN 93	2033	XAN 87	2015	648
Cabudare	VEN	Rio Tibagi	1967	A 237	1535	638
Samán Mocho	VEN	BAT 1432	1401	XAN 87	1272	393
Vallecito	BOL	Jamapa	1850	BAT 1481	1825	461
Graneros	CHI	Jamapa	5868	BAT 1432	5451	1906
Graneros	CHI	CAN 109	4965	Negro G x G.N	4931	714
Santiago	CHI	XAN 109	3774	BAT 1467	3669	966
Chillán	CHI	Jamapa	2962	BAT 1554	2840	486
Alquizar	CUB	Tamazulapa	3337	XAN 87	3257	310
Rapelli	ARG	XAN 93	3125	BAT 1432	3056	489
La Cocha	ARG	XAN 87	2917	XAN 93	2847	662
Delmas	RSA	Kamberg (LC)[a]	2036	BAT 1432	2036	294
Palmira	COL	BAT 1481	2263	BAT 1554	2152	286
Popayán	COL	BAT 1432	3460	A 227	3377	430

[a] LC = local check

Table 99. Yield (kg/ha) of the top two lines for each of the 12 sites where the small, red-seeded entries were tested, IBYAN/83.

Location		Line	Yield	Line	Yield	$LSD_{.05}$
a	TAN	BAT 1289	3115	BAT 1449	2212	1021
Villa Ahumada	HON	BAT 1289	2486	BAT 1572	2375	840
B. San Jose	CRI	Huetar	1875	BAT 1516	1757	206
El Rodeo	NIC	BAT 1493	1072	BAT 1654	934	309
S. Fco. del Valle	HON	BAT 1572	835	BAT 1289	762	261
Alquizar	CUB	BAT 1516	2998	CC 25-9	2990	516
Delmas	RSA	Kamberg	2521	BAT 1432	2174	623
La Cocha	ARG	BAT 1570	2674	BAT 1449	2574	477
Rapelli	ARG	BAT 1570	2812	BAT 1493	2743	720
Palmira	COL	BAT 1532	2253	BAT 1654	2111	435
Popayan	COL	BAT 1526	2719	BAT 1493	2707	658
Popayan	COL	Zamorano	2483	BAT 1493	2398	675

[a] Location unknown

Table 100. Yield (kg/ha) of the top two lines for each of the nine sites where the red-mottled entries were tested, IBYAN/83.

Location		Line	Yield	Line	Yield	$LSD_{.05}$
Palmira	COL	BAT 1297	2562	A 463	2449	274
Tainan	TAW	BAT 1386	1194	A 463	898	318
Alquizar	CUB	A 463	2822	Calima	2781	395
S. Juan de la M.	RDOM	Linea 24	2662	Calima	2645	1272
Delmas	RSA	Kamberg	2189	BAT 1297	2073	300
Central Farm	BEL	Calima	1466	BAT 1367	1462	412
Chipata	ZAMB	A 463	1531	BAT 1386	1280	322
Popayan	COL	BAT 1297	1724	A 469	1160	310
Popayan	COL	BAT 1297	1341	BAT 1367	1011	431

Table 101. Yield (kg/ha) of the top two lines for each of the seven sites where the beans developed for the Mexican highlands were tested, IBYAN/83.

Location		Line	Yield	Line	Yield	$LSD_{.05}$
Palmira	COL	A 442	2046	A 114	1923	320
Popayan	COL	A 445	3198	997 CH-73	3060	652
Popayan	COL	A 445	3557	A 114	3049	708
Zapopan	MEX	II-952-M-26	701	Carioca	651	240
Bukemba	BUR	Carioca	1501	BAT 1671	1493	450
Delmas	RSA	Carioca	2661	Kamberg	2488	634
Chipata	ZAMB	BAT 1671	1496	A 439	1417	473

Table 102. Yield (kg/ha) of the top two lines for each of the nine sites where the cream-seeded entries were tested, IBYAN/83.

Location		Line	Yield	Line	Yield	$LSD_{.05}$
Palmira	COL	A 321	2208	A 301	2128	252
Popayan	COL	A 321	3639	A 292	3349	955
Popayan	COL	A 321	3145	A 292	2697	691
Chore	PAR	A 343	3062	A 292	2937	599
Hacurubi	PAR	XAN 105	1767	A 292	1752	400
Capitan Miranda	PAR	IPA 7419	788	A 344	787	150
Alquizar	CUB	A 359	3282	A 301	2941	502
Delmas	RSA	A 359	1953	Kamberg	1883	454
Mairana	BOL	Catu	3565	A 344	3392	746

Table 103. Yield (kg/ha) of the top two lines for each of the six sites where the cream striped-seeded entries were tested, IBYAN/83.

Location		Line	Yield	Line	Yield	$LSD_{.05}$
Palmira	COL	A 83	2222	A 286	2050	270
Popayan	COL	Ayso	3715	A 445	3675	426
Santa Cruz	BOL	A 445	2125	A 267	1998	1996
Chore	PAR	Ayso	2785	A 271	2767	652
Capitan Miranda	PAR	A 282	863	A 268	820	216
Yaguaron	PAR	Carioca	1419	A 286	1256	372

Table 104. Average yield (kg/ha) of the black-seeded beans tested in CIAT-Palmira and CIAT-Popayan, IBYAN/84A.

Palmira			Popayan		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
2	NAG 55	3086	1	NAG 26	3866
3	NAG 15	2964	2	NAG 42	3740
	Checks				
1	BAT 271 (Local Check)[1]	3524	9	BAT 527 (L.C.)[1]	3264
9	Jamapa (International Check)[1]	2568	12	JAMAPA	3094
	Mean, n= 12	2789			3404
	LSD .05,	753.4			629.9
	.01	1024.0			856.2
	CV	16.0			10.9

Table 105. Average yield (kg/ha) of the small red-seeded beans tested in CIAT-Palmira and CIAT-Popayan, IBYAN/84A.

Rank order	Palmira Identification	Yield	Rank order	Popayan Identification	Yield
	Experimental lines				
1	RAB 59	2989	1	RAB 93	3644
2	RAB 30	2934	2	RAB 71	3584
	Checks				
4	A 21(International check)	2846	6	A 21	3282
9	Zamorano (Local check)	2537	8	Zamorano	3232
	Mean, n= 12	2658			3300
	LSD .05	538.1			465.1
	.01	731.4			632.1
	CV	12.0			8.3

Table 106. Average yield (kg/ha) of the medium-sized, red-mottled beans tested in CIAT-Palmira and CIAT-Popayan, IBYAN/84, Semester A.

Rank order	Palmira Identification	Palmira Yield	Rank order	Popayan Identification	Popayan Yield
	Experimental lines				
2	PV 875	2318	1	PV 1258	3114
3	PV 1360 B	2317	2	A 471	2477
	Checks				
1	BAT 1297 (I.C.)[a]	2552	4	BAT 1297	2276
9	Pompadour Mocana (L.C.)[b]	1967	10	Pompadour Mocana	1596
	Mean, n = 12	2103			2000
	$LSD_{.05}$	391.0			720.8
	.01	531.5			981.0
	CV	11.0			20.8

[a] = International check;

[b] = Local check

Table 107. Average yield (kg/ha) of the large-sized, red-mottled beans tested in CIAT-Palmira and CIAT-Popayan, IBYAN/84 A.

Rank order	Palmira Identification	Palmira Yield	Rank order	Popayan Identification	Popayan Yield
	Experimental lines				
1	MCD 257	2374	1	MCD 257	3545
2	PV 1180	2360	3	PV 359	2235
	Checks				
4	Calima (Local Check)[1]	2128	2	Calima	2243
	Mean, n = 12	2022			2120
	$LSD_{.05}$	326.3			631.8
	.01	443.5			858.8
	CV	9.5			17.6

Table 108. Average yield (kg/ha) of a group of lines developed for the Mexican highlands tested in CIAT-Palmira, IBYAN 1984A.

Rank order	Identification	Yield
	Experimental Lines	
1	A 321	3791
2	A 445	3386
3	A 411	3092
	Checks	
12	G 2858	2528
	Mean (n = 12)	2993
	LSD .05	
	.01	
	CV	7.7

Table 109. Average yield (kg/ha) of the cream-seeded beans tested in CIAT-Palmira and CIAT-Popayan, IBYAN/84A.

Rank order	Palmira		Rank order	Popayan	
	Identification	Yield		Identification	Yield
	Experimental lines				
1	PV BZ 1726	2374	1	PV BZ 1896	4105
3	PV BZ 1701	2282	3	PV BZ 1876	4003
	Checks				
2	IPA 7419[a]	2360	2	Carioca	4063
4	Carioca[b]	2128	8	IPA 7419	3478
	Mean (n=)	2022		3735	
	Range	2374-1673			4105-3376
	LSD .05	326.3			448.4
	.01	443.5			609.4
	CV	9.5			7.1

[a] = Local check; [b] = International check

Table 110. Average yield (kg/ha) of the group of climbing beans developed for cool climates, IBYAN/84A, Popayan

Rank order	Identification	Yield
	Experimental lines	
3	ZAV 8373	3329
5	ZAV 8382	3138
6	ZAV 8385	3051
	Checks	
1	ICA Llanogrande	3450
2	ICA Viboral	3340
4	ICA La Selva 8	3289
Mean, n = 12		2915
Range		3450-2258
$LSD_{.05}$		662.5
$_{.01}$		901.6
CV		13.1

II Evaluation and Improvement of Agronomic Practices

1. On-farm Research

On-farm research in the Bean Program continues with the same objectives described in the 1983 Annual Report, feedback to breeding programs, methodology adaptation, training, and network establishment.

During the year from October 1983 - September 1984, 105 trials were planted in the four work areas in Colombia (Table 111) and 82 further trials were planted in the period August-October 1984. Characterization activities have continued in the four work areas and are described in the economics section of this report.

Feedback to the breeding programs

Extensive examples, for each work area, were given in the 1983 Bean Annual Report. Only a few specific examples for which new information has emerged during the last year will be discussed here.

The mean effect of different factors on bean production across the seasons in on-farm trials conducted in Colombia guides the breeding program priorities. The estimates of yield gains as responses to production factors were generally lower when all the data available up to the end of 1984 were used, compared to the end of 1983 (Table 112). Changes of variety and foliar disease control were important in all estimates (these were measured independently and interactions of variety x disease control were rare). This supports the emphasis given so far in CIAT and national programs to varietal improvement and the incorporation of disease resistance. However, the good response obtained with additional fertilization indicates that the increased work on tolerance to poor soil conditions is appropriate. Although results from a few areas of Colombia cannot be taken as necessarily representative of Latin America as a whole, the work zones do sample a range of typical production problems. The mean estimates of farmers' yields when all seasons are included are very close to present estimates of Latin American bean productivity (600 kg/ha). Four of the six data sets come from intercropped or relay systems with maize, a proportion approximately equal to the frequency of these systems in Latin America.

In selecting new varieties for farmers, it is important to decide how much to reduce the number of advanced lines on the experimental station before beginning extensive on-farm evaluations. Data are now available on this topic from eastern Antioquia and southern Nariño.

In eastern Antioquia, breeding of climbing beans is carried out on the La Selva experimental station under very similar management to that of small farms in the well-developed production area of El Carmen surrounding the station.

Yields of 10 elite lines in La Selva and El Carmen were significantly correlated and their mean was similar (Table 113). However, the correlation coefficient is not a good measure of the results of screening a group of lines to reduce their number. When the data were analysed by rank order, although the variety Llanogrande was top both on-station and on the El Carmen farms, the line which was second on-station (V 6785-325) was second to last on the farms.

Marinilla and San Vicente which are also within 20 km of La Selva, use the same cropping system, have the same altitude and rainfall, but have poorer soils and (in San Vicente) lower management levels. There was no correlation between varietal performance in these areas and La Selva (Table 113). The best two lines in La Selva (Llanogrande and V 6785-325) were the worst ones on farm. One of the two best lines on the farms (La Selva 26) would have been eliminated if fewer than six of the 10 lines were taken from the station to on-farm testing. Two other lines which have proved stable (Viboral and La Selva 1) would have been eliminated unless the entire set of lines had been taken from the station to the farms.

The poor performance of Llanogrande and, especially, V 6785-325 in low yielding environments was confirmed by Eberhart-Russell stability analysis for the four lines which have received the most extensive testing. The farmers' variety, Cargamanto (from which Viboral was selected by ICA), and the promising line ICA La Selva 1 are both type IVb on-station and perform well under lower fertility conditions. Llanogrande and V 6785-325 performed best on station or on very fertile farms, but were inferior to Cargamanto and La Selva 1 on average or poor farms. In eastern Antioquia, changes in plant habit and vigor under farm conditions explained this phenomenon. Cargamanto and La Selva 1 were of type IVb and too vigorous on station, but changed to an efficient type IVa on farms. Llanogrande and V 6785-325 were of the highly productive and efficient type IVas on station, but Llanogrande became a type IIIb of low vigor on average or infertile farms, V 6785-325 suffered this change on all farms.

It should be added that the promising performance of the new variety Gloriabamba on farms in Cajamarca province, Peru, implies that not all genotypes classified as type IVa on station perform poorly on infertile farms.

A similar situation was found in comparing station and farm yields in southern Nariño (Table 114). Yields were not correlated and the lines which were second and third on farms would only have been selected if at least six out of 10 elite lines and been taken from the station to farms.

These results from both eastern Antioquia and southern Nariño suggest that lines well adapted to farms may have been discarded during the reduction to an elite set of 10 lines. Larger sets of advanced lines are therefore being compared on station and farms to estimate under different conditions the number of lines which should be taken for on-farm testing. Parental lines for crosses and segregating generations are also being tested on-farm, to later evaluate the improvement in adaptation to farm conditions of the crosses made and lines selected.

Methodology adaptation

During this second year of intensive on-farm trials in the three work areas of Nariño, the emphasis was on the continuation of variety trials and the expansion of trials for the determination of economic levels and verification trials.

In northern and central Nariño, a limited number of verification trials was planted (Table 111) using the most promising components from 1982B: new variety, chemical fertilizer, foliar disease control, foliar insect control and (in central Nariño only) seed treatment with fungicide. In both sets of trials, the new agronomic practices offered no yield advantage over farmers' practices. In northern Nariño, the promising line ICA L-23 did not maintain the margin of superiority over Diacol Nima which it had exhibited in 1982B, and in central Nariño, the continued yield superiority of Argentino over Ancash 66 was enough to outweigh the slightly higher price of the latter.

The effects measured in 1983B are compared with those from previous seasons in Tables 115 and 116. Particularly in northern Nariño, the large contrast between 1983B and 1982B is cause for concern. The effects in 1983B are more similar to those of 1983A than 1982B, despite the similar climatic conditions in the two B seasons and the dissimilar ones in the A season.

This problem of variability between years is now receiving attention to develop a strategy of trials by which national personnel may overcome this problem, without greatly delaying the progress of on-farm research.

In southern Nariño, where 14 verification trials were planted on a wider information base from previous years, little problem of year-to-year variability occurred. The results of these trials are discussed later.

In Antioquia, the only technologies to reach verification have been the use of the new line ICA La Selva 1 and the new variety ICA Llanogrande, and, in the less-developed subzones, increased bean planting density as well. There has been little problem of consistency from year to year with these simple technologies.

Training

For the first time an intensive specialization for seven weeks was given to 12 participants from Colombia, Ecuador, Peru, Costa Rica, Guatemala and the Dominican Republic. It was judged a success by the participants, who are all active in on-farm research either as station researchers, members of technology testing teams, or in extension. Three weeks were spent carrying out the practical activities of on-farm research: diagnosis, trial planting, management and harvesting in the ICA-CIAT work areas of Colombia. This was supported by class sessions in which analysis, reporting, and the connection between diagnosis and trial design were emphasized. Roundtable discussions and group exercises were used extensively. The specialization will be repeated in 1985. That year will also see the commencement of the first in-country course on on-farm research to be conducted in three phases in Cajamarca province, Peru with approximately 18 participants. Also scheduled for 1985 is a regional course for Central America to train participants in on-farm variety testing at different technology levels, based on farmers' cropping systems and practices.

Network establishment

Bean Program staff have been active, with other programs in CIAT, in establishing links between international and national centers active in on-farm research. The initial objective is to improve interchange of information, training materials and support between those active in this field: (a) in Latin America where initial discussions have taken place between CIAT, CIMMYT and CIP; and (b) in eastern and southern Africa where an inter IARC consultation on systems-based research was held. As a result of the latter, on-farm research training activities with the collaboration of various IARCs are projected for the Great Lakes Region of east-central Africa.

On a more informal level, a network of collaborators is being built around those who have been trained in on-farm research at in CIAT, and others. Costa Rica is one of the first countries to receive intensive support in on-farm research in beans. CIAT staff participated in a planning meeting to coordinate experimental station and on-farm research and followed this up with field visits in the two cropping seasons.

Training materials and conference papers from CIAT and sister institutions are also circulated to network contacts to improve the exchange of information and ideas.

Technology adaptation to specific areas

Technology adaptation is not a primary objective of CIAT's participation in on-farm research, although it is achieved indirectly through support given to national programs participating in the network activities. However, results from the Colombian on-farm research activities in collaboration with ICA show the potential of OFR to provide rapid results. The strongest example has been in southern Nariño, where the climbing bean line Ecuador 605 has entered the farmers' cropping system in association with maize, partly displacing the local cultivar Mortiño.

Because Ecuador 605 had shown promise for three years in station trials it was planted in 1981 in two on-farm trials where it performed well. In 1982, when intensive on-farm research began in southern Nariño, it was tested in four variety trials, six exploratory trials and four fertilizer trials in which it showed a consistent superiority of approximately 250 kg/ha over Mortiño, whatever the level of technology applied. In 1983, it was therefore planted in all 32 farm trials in the zone, of which 14 were verification trials with only one replication per farm, a plot size of 100-120 m^2 and with farmer participation not only in management but in planting. Ecuador 605 outyielded Mortiño by 226-318 kg/ha depending on the level of technology employed (Table 117). It was actually more favored with the farmers' present technology than with increased density and disease control. Disease control with Benomyl in 1983 was less effective than in 1982B. Net benefits were calculated assuming a Col$ 10/kg discount for Ecuador 605 over the Col$ 130/kg farm-gate price of Mortiño. The economically efficient treatments were: Ecuador 605 with farmers' technology; and Ecuador 605 with the highest level of technology.

Observations in a farm trial in 1982B suggested that Ecuador 605 might have resistance to Fusarium root rot which is a severe problem on a minority of bean fields in the area. A trial planted in 1983B, on fields known to be infected, confirmed that Ecuador 605 actually outyielded on these fields the line Potosi 1 which was specifically selected by the University of Nariño for its root rot resistance (Table 118). This is an added advantage of Ecuador 605 for farmers.

Farmers who had managed a trial which included Ecuador 605 were asked an open-ended question of their opinion of the line. The results (Table 119) show that farmers clearly appreciated the positive features of the line with the exception of earliness (about three weeks earlier to harvest than the 7.5 to 10 months of Mortiño).

As the final stage of on-farm research trials with Ecuador 605 in Nariño, 12 semi-commercial production plots of 1000-3000 m^2 are being planted by farmers alongside their present variety Mortiño. No other new practices are included in the trial; in view of the adaptability of Ecuador 605 the farmers are free to employ their usual practices. In addition, 18 farmers who previously had trials with Ecuador 605 have requested seed and 88 kg has been distributed by ICA, but others may have taken seed from trial borders. Seven farmers report having sold Ecuador 605 in commercial quantities from the borders left in experiments on their farms. Six mixed the seed with Mortiño. They claimed that prices had not been depressed as a result. The liberation of Ecuador 605 by ICA is expected in 1985, but it is clear that its natural diffusion has already started among farmers and intermediaries.

In eastern Antioquia, sufficient data has been collected in the period 1982A-1984A to compare the performance of the promising line ICA La Selva 1 and the released varieties, ICA Llanogrande and ICA-Viboral, with the farmers' variety Cargamanto (Table 120). In

El Carmen, the most developed area, Llanogrande outyielded Cargamanto and La Selva 1, but cnly just sufficiently to compensate for its 15-20% price discount. La Selva 1 (a Cargamanto seed type but with anthracnose resistance) might offer a possibility of diversifying the narrow genetic base of bean germplasm used in the area provided there is no price discount since it yielded approximately the same as Cargamanto. In Marinilla, La Selva 1 showed a yield advantage over the other varieties. In San Vicente, where agronomic practices are least developed and soils poorest, La Selva 1 showed a clear advantage over Cargamanto, and would also be preferred to Llanogrande, whose yields were insufficient to compensate for its price discount. The variety ICA Viboral, selected from Cargamanto collections and released some years ago, was not consistently superior to Cargamanto in yield. ICA is expected shortly to release La Selva 1 as a variety.

Table 111. Number and type of trials planted on farms in different regions of Colombia, 1983B & 1984A.

Type of trial	Eastern Antioquia 1983B	Southern Nariño 1983B	Central Nariño 1983B	Northern Nariño 1983B	Eastern Antioquia 1984A
Variety					
Parents, segregating generations or advanced lines	-	1	1	1	4
Bean varieties	7[a]	4[a]	4	3	3
Maize varieties	b	-	-	1	-
Exploratory trials (training purposes)	-	-	-	-	3
Determination of economic levels					
Variety x cultural practices	12[ac]	-	-	-	-
Fertilizers	-	4[a]	3	3	-
Seed and soil treatment/seed purification	3	4[a]	b	4	-
Fertilizer application methods	-	2[a]	b	b	-
Intensification of cropping cycle	-	4[a]	-	-	-
Verification trials	7	14[a]	4	3	6
TOTAL	29	33	12	15	16

[a] Copy of trial planted on nearby experimental station for comparison

[b] Included in another type of trial

[c] Eight trials in relay with maize, four in bean monoculture.

Table 112. Mean response of beans (kg/ha) to production factors in the work zones in Colombia, 1982-1984.

	Estimates after 1984A harvest		Estimates after 1983A harvest	
	Main season[b]	All seasons[c]	Main season	All seasons
Additional fertilizer[a]	178	146	202	162
Most promising new variety with acceptable seed type	142	113	289	211
Foliar disease control	141	107	284	202
Density increase	127	112	150	127
Seed treatment with fungicide	111	76	116	79
Foliar insect control	68	48	138	83
Soil treatment with insecticide	50	30	39	26
Mean farmer's yield	723	588	735	596

[a] 200 or 250 kg/ha of 13-26-6 or 10-30-10 ($N-P_2O_5-K_2O$) in addition to farmers' present fertilizer usage.

[b] Mean of principal growing season in each of the four work areas.

[c] Also includes minor growing season in central and northern Nariño, in which drought is a problem.

Table 113. Comparison of station and farm yields of climbing bean elite lines in eastern Antioquia, 1982-1984.

Line or variety	La Selva experimental station (4 trials)	El Carmen (well developed) (6 trials)		Marinilla and San Vicente (less developed) (6 trials)	
	Yield (kg/ha)	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank
Llanogrande	2149	1824	1	441	9
V 6785-325	1852[1a]	1323[4]	9	412	10
La Selva 7	1771	1483[2]	4.5	599	3
La Selva 4	1706	1507	2	634[1]	1.5
V 5783-38	1669[1]	1384[4]	8	491	6.5
La Selva 26	1661	1418	7	629	1.5
La Selva 13	1486[1]	1475[4]	4.5	496	6.5
La Selva 1	1452	1465	4.5	535	5
La Selva 18	1413	1257[2]	10	467[1]	8
Viboral	1344	1467	4.5	552	4
Mean Yield	1650	1460	-	526	-
LSD (5%)	338	223	-	142	-
Correlation with station yield	-	0.61 (P=0.06)	-	-0.24 (P=0.50)	-

[a] 1,2,4 = number of trials in which this line was not tested. Weighted estimates of yield were calculated.

Table 114. Yields of promising lines or varieties (kg/ha) on farms in southern Nariño compared to station yields in Obonuco. When lines were not included in a trials, a weighted estimate was calculated from their percentage change over Mortiño in other trials.

Line or variety	Mean yield farms	Mean yield Obonuco	No. of trials on-farm	No. of yield trials on-station	Rank on station
32980-1-41	754	2170	7	2	3
32980-1-44	647	1810	7	2	5
Ecuador 605	638	1622	7	6	6
32980-1-43	458	2684	4	1	1
ICA M8	457	1145	7	6	9
32976-1-41	450	2194	4	1	2
L 33003	437	1245	4	5	8
Ecuador 521	430	1843	4	5	4
Mortiño (farmers' variety)	418	1087	7	10	10
Llanogrande	235	1584	4	5	7
Mean Yield	492	1738	-	-	-
LSD (5%)	170	360	-	-	-

Correlation between farms and station = 0.27 NS

Table 115. Change in bean yield (kg/ha) for climbing beans in response to changes in production factors in northern Nariño in 1983B, compared to previous seasons. No. of trials is in parentheses. No interactions between factors were detected.

	Mean 1983B	Mean 1982B	Mean 1983A
Change of bean variety			
Nima to ICA L-23	-92(4)	231(2)	-113(4)
Nima to Argentino	151(2)	-202(2)	112(4)
Pre-soaking of seed in benomyl	-88(5)	-54(1)	-
Fertilization with 300 kg/ha 13-26-6	134(5)	315(4)	90(6)
Control of foliar insects and diseases	-259(3)	355(4)	76(6)
Change of maize variety from Morocho blanco to MB 311			
Effect on maize	945(1)	564(1)	-
Effect on beans	91(1)	0(1)	-
Farmers' yield: Beans	907	537	252
Maize	2100	800	300

Table 116. Change in bean yield (kg/ha) for bush beans in response to changes in production factors in Central Nariño in 1983B compared to previous seasons. No. of trials in parentheses. No interactions between factors were detected.

	Mean 1983B	Mean 1982B	Mean 1983A
Change of bean variety			
Limoneño to Ancash 66	596 (3)	213(7)	30 (3)
Ancash 66 to Argentino	222(10)	254(7)	277(10)
Seed treatment			
Soaking in benomyl	187 (3)	316(2)	-
Carboxin powder	61 (3)	-	11 (4)
Seed purification in disease-free environment	216 (3)	-	-
Increase in fertilizer use			
From 100 to 300 kg/ha 13-26-6	162 (7)	360(3)	50 (3)
5 kg/ha Zn	238 (1)	223(1)	-
Combined phytosanitary practices			
Foliar disease and insect control, seed soaking in benomyl	25 (4)	612(3)	65 (4)
Farmers' yield (Argentino)	960	978	386

Table 117. Comparison of Mortiño and Ecuador 605 at different technology levels. Verification trial, southern Nariño, 1983-1984. (Mean of 13 farms).

	Farmers' technology		Improved disease control		Improved disease control + increased bean density	
Bean variety	Mort	E 605	Mort.	E 605	Mort	E 605
Bean yield (kg/ha)	575	892	601	903	817	1043
Maize yield (kg/ha)	1627	1958	2074	1924	1750	1631
Variable costs ($Col/ha)	10367	9462	10438	9533	13995	12163
Net benefit ($Col/ha)	117464	164892	139994	164679	150585	166250

Fixed costs : $Col 16880/ha

LSD (10%) for yields: beans 239 kg/ha, maize 324 kg/ha

Table 118. Differences in varietal response (kg/ha) in fields with and without *Fusarium* infection, southern Nariño 1983-84.

	One farm with severe infection		Two farms without infection		Maize yield (farmer's variety) Mean 3 farms
	Bean yield	% plants harvested[a]	Bean yield	% plants harvested	
Ecuador 605	980	82	641	55	1933
Potosí 1	921	75	615	50	2078
Mortiño (farmers' variety)	222	57	697	60	2070
LSD (10%)	138	11	128	8	191

[a]As % of seeds planted

Table 119. Opinions of farmers who are familiar with Ecuador 605 from the trials. (Sample size 20 farmers, June 1984).

Characteristics of E 605	%
Yields more	65
More resistant to anthracnose	65
Can be sold alone or mixed with Mortiño	40
Uniform with good seed weight	30
Resistant to root rots	10
Early	5
Small seeds	20
Sensitive, no market	5
No opinion	10

Table 120. Comparison of varietal performance (kg/ha) in relay with maize in different areas of eastern Antioquia. Summary of results 1982A - 1984A.

	El Carmen		Marinilla		San Vicente	
Line or variety	All 21 Trials	Best 9 Trials	All 15 Trials	Best 6 Trials	All 15 Trials	Best 6 Trials
La Selva 1	1307	1628	878	1460	785	1133
ICA Llanogrande	1612	2108	751	1299	760	1256
Cargamanto	1327	1676	773	1092	588	856
ICA Viboral	1378	1663	737	1193	612	906
LSD (10%)	155	252	142	292	129	303

2. Economics

Research in bean economics includes production, marketing and consumption, and policy studies. Production research focuses on two mutually reinforcing themes: assessment of the spread of new varieties recently released to farmers by national programs; and assessment of farmers' current production systems and problems. Consumption and marketing of beans remain important research topics because most beans in Latin America are produced for the market, thus making consumer acceptability, price, and ease of market entry critical factors in determining farmer adoption of new bean varieties. Case studies of policy affecting bean production and markets are undertaken when policy is seen to have an important impact on the environment for which new technology is being developed. A great deal of the research on all these issues is conducted in collaboration with national programs, and strengthening their research capacity through training and collaborative projects is an important activity.

Adoption studies

In recent years a large number of varieties selected in joint national program-CIAT research activities have been released by national programs for farmer use. Study of the diffusion of these varieties can:

(1) Provide important feedback to bean scientists on the characteristics that could usefully be incorporated in future varieties.

(2) Identify constraints to diffusion of new varieties, be they seed supply, extension, markets, varietal characteristics or farmer resource limitations.

(3) Assess the socio-economic impact of new technologies, initially on producers, but ultimately on consumers as well and for society as an aggregate.

Argentina. By means of international yield trials (IBYAN nurseries) first distributed in 1979 to the Estacion Experimental Agro-Industrial Obispo Colombres, INTA, and the University of Cordoba, superior black bean materials have been identified for release to farmers. In 1984, an EEAOC - CIAT collaborative project was initiated to assess the degree of adoption, constraints, and the impact of new black bean varieties in Argentina. A questionnaire was jointly prepared, while EEAOC selected a 15% sample of bean farmers, conducting interviews with 183 farmers in the principle bean producing states of Jujuy, Salta, Santiago del Estero and Tucuman (which account for 94% of bean production).

While detailed analysis of the survey data is currently being carried out by an EEAOC economist, preliminary results (subject to future revision) suggest that in 1984 improved varieties (DOR 41, BAT 304, BAT 448) were grown by 65% of the sample of black bean farmers on 65% of the area sown to black beans (Table 121). The line DOR 41, developed in a joint project between ICTA and CIAT (released in Guatemala as ICTA-Quetzal) is the principle new variety being grown. Yields of the new high yielding varieties average 1367 kg/ha, a 26% increase over local black bean material (Negro Comun). Among sample farmers alone, new black bean varieties were grown on over 7400 ha., and an estimated total of 26,000 ha. were sown to the new varieties in 1984.

Preliminary inspection of the survey data indicate that farmers have not in any way modified their production practices apart from changing the variety. Net returns (NR) to farmers were calculated by

$$(1)\ NR=(P * MY) - MC$$

where P is the Argentine farm price for black beans at the 1984 harvest;
MY is the marginal increase in production due to the new varieties; and
MC is the marginal cost of sowing the new varieties (increased seed cost).

Based on these calculations, Argentine bean growers are estimated to have obtained a net benefit from the new varieties in 1984 of US$2.15 million, while earning a marginal return on capital of 651%. The 1984 Argentine black bean harvest was mostly exported to Brazil. Though the increased output due to the new varieties was large for the farmers, even assuming that all the additional output entered the Brazilian market, it represents an increase in supply of only 0.3%, so it is unlikely to have had a significant negative effect on farm level prices.

Benefits from the new bean varieties have accrued to farmers in Tucuman, Santiago del Estero, and southern Salta where on-farm trials were conducted to select the new varieties. The HYV's (high yielding varieties) have also spilled over into central and northern Salta (Table 121), where they seem to be less well adapted. Trials are currently being conducted in these regions to identify materials better adapted to conditions there.

<u>Colombia</u> In 1982, ICA released the climbing bean variety ICA-Llanogrande (formerly reported as E 1056) after two years of on-farm trials in eastern Antioquia conducted jointly by ICA and CIAT. Three surveys conducted in eastern

Antioquia in 1984 with a total of 185 farmers found few farmers aware of the new variety and that adoption of Llanogrande in the region was consequently negligible. In order to obtain a better understanding of farmers' attitudes to ICA Llano- grande, a follow up study of 22 farmers known to have been exposed to the new variety was conducted with the collaboration of ICA. Three principle factors determined farmers' attitudes towards the new variety.

(1) Given the high price and ease of marketability of the traditional local variety, Cargamanto, farmers in eastern Antioquia were reluctant to shift to a variety that receives less favored treatment in the market.

(2) Although ICA Llanogrande is more anthracnose - resistant than Cargamanto, farmers are not disposed to reduce frequency or dosages of fungicides because they view preventive disease control as indispensable in bean production and as a fairly small component of total costs. Reduced spraying costs were seen as one of the main economic advantages of adopting Llanogrande (Bean Annual Report, 1981; 1982), but farmers' insistence on the security of preventive disease control removes one major economic incentive for adoption.

(3) While reduced vigor to permit higher density sowing was an important selection criteria (Bean Program Annual Report, 1981), farmers perceived the less vigorous Llanogrande as simply weak, and are not aware of the recommendation to plant it at a higher density than the traditional variety.

Faced with these three constraints on the acceptability of Llanogrande in eastern Antioquia, ICA's current strategy is to promote its transfer to other regions.

Of greater impact so far in eastern Antioquia has been the spread of improved anthracnose control practices identified in ICA-CIAT on-farm trials and promoted through ICA extension. Benomyl has now been adopted by 47% of farmers in the region despite its higher cost (van Herpen et al). Farm trial and survey data gathered from 1979-84 show an average yield gain of 209 kg/ha with the new practice. The value of the additional bean production due to improved disease control, and net of its additional cost, is estimated at US$ 2.6 million in 1984.

Costa Rica A series of studies has followed the spread of new bean varieties in Costa Rica. A 1982 IICA survey in southern Costa Rica found that 34% of small farmers were using new bean varieties, mostly Talamanca, an ICA line introduced to Costa Rica through the CIAT Central American project. In 1983, the department of Agricultural Economics of the University of Costa Rica in conjunction with CIAT, undertook a larger scale survey in the southern region that found 61% of farmers growing Talamanca in the main spring planting on 47% of their area in beans. The average reported yield of Talamanca was 1052 kg/ha compared to 944 for the widely grown introduced variety Jamapa, and 600-700 kg/ha for traditional local varieties.

Farmers report a preference for the erect architecture of Talamanca which lessens diseases in rainy conditions, and 96% intended to continue growing the new variety. The only major change in farmer practices noted is that 37% of farmers have increased planting density with the new variety. Use of Talamanca was observed to be higher in the main wet season spring planting than in the fall dry season planting.

In 1984, 106 farmers were interviewed in a rapid appraisal of bean production in four regions of Costa Rica (the south, the Meseta Central, Upala and Guanacaste) which indicated the spread of Talamanca in all regions, with highest levels of adoption being observed in the more important bean producing regions of the south and Upala. A survey was also initiated in 1984 to assess in detail the adoption of Talamanca in the fall dry season planting, but these data are still being collected.

Guatemala. Three new black bean lines (Quetzal, Tamazulapa and Jutiapan) with resistance to the bean golden mosaic virus (BGMV) have been developed in collaboration between ICTA and CIAT. The performance of these varieties was assessed through an extensive set of trials conducted by ICTA on small farms in southeast Guatemala from 1979 to 1982, while in 1983 DIGESA, the extension service, managed over 200 demonstration plots of the new varieties in farmers' fields. The ICTA socio-economics unit has been actively appraising the new varieties, and in collaboration with CIAT undertook in 1984 a survey of a sample of 94 farmers who had received the new varieties from the extension service in 1983 to see if these farmers grew these varieties commercially in 1984.

While these survey data have yet to be fully analyzed, preliminary partial results (subject to future revision), show that 67% of farmers who had been exposed to the new varieties are now growing them commercially and they cover 39% of the area sown to beans. Farmers report an average yield of 909 kg/ha with the new varieties, a 20% increase over the reported farmer yield of 756 kg/ha with traditional varieties (Table 122). Besides yield, most farmers also comment favorably on the more erect architecture of the new varieties which they say is an advantage when rains are heavy.

The new varieties are being grown by a similar proportion of sample farmers regardless of farm size (Table 122). They are also being grown with the same frequency of fertilizer use as traditional varieties. The survey data also show a similar frequency of cropping system between the new varieties and the traditional ones.

Although 26% of the sample farmers have completely replaced traditional varieties with the new ones, the more common strategy is to grow both. The new varieties are some two weeks later than the traditional, so they are viewed by farmers as more vulnerable to late season drought stress. Thus, many farmers opt for a portfolio of varieties of different maturities to benefit from the high yield potential of the new varieties while spreading their risk.

Production research

Production research continues to focus on identification of constraints and research opportunities in the design phase of technology development to provide bean researchers with insights as to the type of new varieties that farmers find useful. This includes both target area characterization and preliminary evaluation of technologies in development. Economic analysis of the results of 1984 ICA-CIAT on-farm trials in Colombia are reported in the on - farm research section of this report.

Bean systems studies: Colombia. A farm system perspective was employed to assess the feasibility of introducing short season bean varieties currently being tested in ICA-CIAT on-farm trials in southern Nariño. Such new bean varieties would change not only maize varieties but also imply changes in crop rotations. Interviews with key informant farmers in southern Nariño found that most saw merit in short season maize and beans that would permit taking another crop. A survey showed that land use is indeed intensive, and only a minority of large farmers occasionally leave land in fallow. Analyses of farmer rotations, planting dates, turn around time, and crop growth cycles indicated that of commercially important crops currently grown by these farmers, potatoes, barley and peas could be grown compatibly with short season maize and beans. Wheat and broad beans have too long a growth cycle to be components in a more intensive crop rotation. Vegetable crops are also unsuitable because they are grown in rotation with potatoes rather than maize/beans, and also due to high capital requirements and narrow markets that restrict the farmers' ability to plant vegetables.

Currently, available short season varieties would permit the growing of two cycles of maize/beans and one of another crop during a two year period. To achieve this, it may be convenient to move maize/bean planting dates slightly forward and slightly back in alternative years. Thus, it may be useful to test the sensitivity of short season maize and bean varieties to planting dates.

Evaluation interviews were conducted with farmers participating in the 1983 ICA-CIAT on-farm trials in Central Nariño where promising results had been obtained for the new variety Ancash 66. Since Ancash 66 is nearly two weeks later than traditional varieties, it may not be easily compatible with taking a following crop of wheat or peas as is normal when beans are grown in monoculture. However, lateness may not be a problem when beans are grown in association with maize since the later maturity of the maize prevents taking a second crop.

A subsequent survey showed that although monoculture is the principle bean system in the region, accounting for three-fifths of the area sown to beans, most farmers (72%) grow at least one plot in maize-bean association to meet their personal consumption requirements of maize. Therefore, the 1984 ICA-CIAT on-farm trials in central Nariño are testing for the first time the performance of Ancash 66 in association with maize.

Surveys on bean production systems were also conducted in Antioquia, Colombia. In a study of a single village several novel observations were made. Formerly, it was thought that farmers utilized almost exclusively climbing beans in relay with maize, it is now known that for many farmers climbing beans in monoculture with artificial support has become an important system. Moreover, a substantial minority of farmers are now using herbicides to substitute for labor in land preparation. These trends were also observed (though sometimes less intensely) in a survey of five villages in Antioquia. Therefore, the implications of bean monoculture and the increasing use of herbicides for ongoing ICA-CIAT on farm trials in Antioquia is currently being considered.

Bean Systems: Costa Rica. A rapid reconnaisance of four major bean producing regions in Costa Rica was undertaken to orient future studies. A critical factor distinguishing farmer bean production systems in Costa Rica is the planting system (Table 123). The traditional "tapado" shifting cultivation system of slash and broadcast has long been the most prevalent production system in Costa Rica. This system has the advantages of high labor productivity due to low labor inputs while the mulch of weeds from the slash land preparation both provides erosion protection and aids in limiting the spread of web blight. However, the rapid appraisal suggests that among small farmers in more densely populated areas (eg. Perez Zeledon) there is a tendency to shift to planting with the digging stick "Espequeado" to obtain both higher yields and more intense land use.

Since there are important differences in the characteristics of bean material optimally adapted to each system, a more careful study of the comparative advantages to farmers of the alternative systems is now underway to help determine the balance of attention of bean researchers between the two systems.

Bean Systems: Guatemala. Information on farmer production systems and their principle problems is being generated as a by-product of the study of adoption of new bean varieties in southeastern Guatemala. For example, preliminary survey results of a sample of small farmers (57% have less than 3.5 ha) suggest that fertilizer use is quite widespread, across all cropping system while chemical disease or insect control remains relatively uncommon (Table 124).

The same survey found that farmers agree with bean scientists that BGMV is generally the most important production constraint, followed in order by Chrysomelids, slugs, foliar diseases and *Apion* sp.. However, problems faced in 1984 differed significantly from the normal (Table 125). BGMV was not observed as frequently, and this may account somewhat for farmers' failure to cite superior BGMV resistance as a characteristic of the new varieties. Heavy rain leading to excess moisture was the most notable problem in 1984, and this may have contributed to the strong favorable impression made on farmers by the upright architecture of the new varieties.

Production trends: Africa. Since the Bean Program is currently intensifying the scale of its work in Africa, an assessment of recent trends and the general structure of production and consumption of beans in Africa has been conducted. Africa is the world's second leading producer of beans (after Latin America), and 110 million people in sub-Saharan Africa live in countries where beans are the leading non-cereal source of protein. In many countries growth in bean production is lagging behind population growth, leading to declining per capita bean consumption at the same time that consumption of other food staples is dropping. Moreover, growth rates declined notably in the 1970's. Yields have long been stagnant but during the 1960's many countries were able to increase production by expanding the area planted to beans. However, this area expansion has not been sustainable, particularly in countries like Burundi and Rwanda where population densities are very high.

Beans are cultivated principally by small farmers in Africa, often in mixed cropping systems and in varietal mixtures. Typically most production is for subsistence, and the use of agro-chemicals is negligible. Because beans are produced in a diversity of cropping systems and environments further studies on production systems and consumer preferences are being undertaken by CIAT in collaboration with national programs, and results are reported in the African regional project report.

Marketing/consumption studies

Since most beans in Latin America pass through the market before reaching the consumer, price and income elasticities of demand, consumer preferences, market structure and nutrition can all be important influences conditioning the chances of success of new varieties. A wide variety of methodologies are being utilized to assess the issues

Brazil demand elasticities. Demand parameters are needed to appraise the market response to an increased supply, and can be used to estimate expected bean prices after technical change, or to estimate the distribution of benefits of new technology between consumers and producers. In 1984, data were analyzed from a survey of Brazilian food consumption conducted by Fundacao Instituto Brasilero de Geografia e Estatistica. A double log quadratic consumption function was estimated (standard errors are in parentheses).

$$
\begin{aligned}
1\ QF = & -1.63 + 1.50 \ln Y - 0.11 \ln y^2 - 1.76 \ln PF \\
& \quad (1.44) \quad (0.31) \qquad (0.02) \qquad (0.99) \\
& + 0.14 \ln YP + 0.41R + 0.15N \\
& \quad (0.12) \qquad\quad (0.04) \quad (0.07) \qquad R^2 = .77
\end{aligned}
$$

Where QF = per capita consumption of beans
Y = per capita total expenditures
PF = price of beans
YP = interaction bean price by total expenditures
R = dummy variable for rural
N = dummy variable for northeast

Estimated price and expenditure elasticities of demand are presented in Table 126 by income quartiles.

Market Structure, Medellin. While estimation of demand parameters is useful for describing aggregate market behavour, consumer attitudes to grain type and cooking characteristics are important issues for beans, as these preferences contribute to price differentiation in the market. Therefore, considerable attention is devoted to assessing consumer preferences and price differences in order to guide program scientists in the selection of new, commercially acceptable materials.

A study of the bean marketing system in Medellin, the largest bean market in Colombia, found a much greater diversity in commercial bean types than previously thought. While this study was highly consistent with the 1983 consumer survey with respect to total bean consumption (13.9 vs. 14.5 kg/capita/year), it found that the preferred high price Cargamanto variety occupies a lower market share

(45.1%) than the consumer survey suggested (65.4%) since consumers seem to have overestimated their Cargamanto consumption, presumably due to its higher status. (Table 127).

Consumer preferences in Medellin. The diversity of preferences and their relation to economic factors were confirmed by in-depth interviews with a 10% subsample of the original 260 households surveyed in 1983. This study found that in the two upper income quartiles, housewives have a clear preference for large round high priced grain types (Cargamanto and Radical), but low income housewives do not express this preference, seeking above all, a low priced bean.

In all families, plantains are added to the beans in cooking, but the poor report doing it to increase the volume of food, while the better off do it to improve taste. Moreover, the poor use two and a half times as much plantains per kilo of beans as do the rich. Because the use of artificial coloring is rejected by all income strata in Medellin, the poor prefer a bean with a darker broth that maintains color better when stretched out with plantains. Cargamanto does not give a dark broth, but this is not a problem for the better off who use less plantain with beans (Table 128).

Although consumers perceive little difference in cooking time among commercial varieties, poor women are concerned about cooking time of beans since they are busier working and can expect less help from servants or relatives in food preparation. Consequently 67% of the poorest quarter of housewives report that if they are busy, they will not prepare beans compared to only 17% among the high income quartile. Two-thirds of the poorest housewives expressed interest in new beans of a considerably shorter cooking time, compared to only 14% of upper income quartile housewives.

Many low income housewives also prefer varieties of a high water absorption capacity, because such beans are more filling. Since there is an inverse correlation between size and water absorption capacity, this encourages poor families to purchase small beans. Finally, high income housewives tend to purchase Cargamanto or Radical fairly automatically, and they are less responsive to price changes. Poor consumers are more likely to vary the type of beans they buy based on price and availability, and are more prone to comparison shop to find the best bean at a reasonable price. Thus, Cargamanto is less dominant in Medellin than previously thought and the well known preference for Cargamanto reflects primarily the tastes of the well-to-do which in many ways does not meet the criteria of the poor consumer.

Hedonic prices model. Knowledge of consumers' bean preferences can offer important guidance in the determination of selection criteria for new materials, but often it is useful to be able to assign an economic value of particular traits. To test the utility of a hedonic prices model, a sample of 31 bean merchants in Cali, Colombia were asked to estimate prices of eight different grain types in terms of color and shape, with each grain type also being presented in different sizes. All commercial grain types in the Cali market were included though not identified.

A hedonic model regressed price on weight, shape and dummy variables for color groups (Table 129). In an alternative specification, the estimated price of the principle commercial variety was included to account for any systematic bias for a merchant to quote consistently high or low prices.

Prices estimated from the hedonic model correspond very closely to observed market prices, suggesting that the model performs well (Table 130). Thus, the model is used to estimate expected market prices of promising lines, and these prices can be used together with yield data to assess the profitability of new varieties.

Other studies. As part of larger studies, the nutritional role of beans in Latin America and the bean program strategy toward nutritional objectives have been reviewed. CIAT focuses on increasing yield production technology to increment farmer incomes and lower consumer prices, thereby permitting improved nutrition through increased consumption. While consumer acceptance factors, especially grain type and cooking quality are given high priority in varietal screening, there is currently little emphasis on protein content or amino acid balance because of lack of market incentives for farmers to grow such varieties; strong environmental interactions; and lack of suitable screening techniques.

Policy studies

Small farm technology. The technical, economic, and political feasibility of developing new bean technology biased in favor of small farmers is an important concern of the CIAT bean program. Adaptation to associated cropping systems, plant architecture, and stress tolerance under low input conditions may all contribute to biasing new varieties in favor of small farmers. Where small farmers are competing with large farmers, small farm biased technical change can lead to benefits for small farmers, even if net producer benefits are negative due to price declines induced by increased supply. However, scale neutral technology may leave small farmers relatively worse off both because they tend to lag behind large farmers in adoption and also because of net producer losses that so often accompany technical change in agriculture. The potential benefits of small farm biased technology need to be weighed in the light of typically higher research costs due to intense and multiple stresses as well as less wide adaptability.

International trade. Trade in beans is considered both from the point of view of low income country exporters seeking access to the international market, as well as the impact of imports on bean producers in importing countries. Colombia traditionally was a very minor importer of beans. However, in 1981 bean imports to Colombia rocketed to equal one-third of domestic production due to a combination of an over-valued currency and a fall in international prices as U.S. exporters were left with a substantial surplus when the Mexican market dried up as production there recovered.

When North American imports were curtailed in 1982, there was an import surge from Ecuador due to the substantial devaluation of the sucre. After this, trade was restricted in 1983 by banning private trade in beans, but bean imports through public sector channels remained at a level twice that of the historic high volumes before 1982.

The inflow of bean imports first reduced farm profitability of bean production, then left the consumer facing high bean prices as imports were cut off. The current more restrictive import policy and resultant high prices provides a strong stimulus to bean production and investment in new technology in Colombia.

Training

Often socio-economic research capacity is a particularly neglected area in national agricultural research programs, so strengthening socio-economic research capability is receiving increasing attention. The emphasis in economics training has been on learning-by-doing through collaborative research projects. Visiting economists from Argentina, Costa Rica, and Guatemala came to CIAT Palmira for practical experience in primary data gathering and data analysis. Student thesis projects were supervised in Colombia on bean marketing issues, and in Costa Rica on the spread of new varieties.

Intensive practical training in rapid survey techniques and economic analysis of trials were given to agricultural researchers and extensionists from Colombia, Costa Rica, Ecuador, Guatemala, Peru and the Dominican Republic as part of the course in on-farm research conducted at CIAT. Lectures on survey and economic methodology were presented at an in-country training course held in Peru; at a regional bean production course for Central America and the Caribbean held in Guatemala; at an ICA course for regional economists in Bogota; at a FEDECAFE course on bean production in

Palmira, Colombia; and in the multidisciplinary phase of the bean course in CIAT. A post-doctoral fellow spent two months in orientation at CIAT prior to assignment to Rwanda, while an economist from a Title XII CRSP in Tanzania came to CIAT to be exposed to research approaches used here.

Table 121. Adoption of new black bean varieties (DOR 41 and other high-yielding varieties), Argentina, 1984

Region	% Farmers growing HYV[a]	Area in DOR 41 (%)	Total area in HYV[a] (%)	Yield HYV (kg/ha)	Yield Negro Comun (kg/ha)
Tucuman/Santiago del Estero	96	78	96	1511	1010
Southern Salta	54	39	54	1368	1006
Central and North Salta	42	39	55	1004	1197
Average	65	50	65	1367	1088

[a] HYV = high yielding varieties.

SOURCE: Preliminary results from EEAOC survey From a 15% sample of bean farmers.

Table 122. Use of new and traditional varieties by cropping system, and their yield, southeast Guatemala, 1984.

	Beans in monoculture	Maize + beans	Maize + Beans + Sorghum	Total
New varieties: % of plots	15.2	24.1	4.8	100.0[a]
Old varieties: % of plots	15.2	22.8	11.7	100.0[a]
New varieties: yield (kg/ha)	1099	818	835	909 (average)
Old varieties: yield (kg/ha)	820	725	661	756 (average)

[a] Includes minor combinations such as beans + sorghum

SOURCE: survey data

Table 123. Some characteristics of three bean production systems in four regions in Costa Rica from a rapid appraisal, 1984.

	"Espequeado" % planted	"Tapado" % broadcast[a]	Use of new varieties[b] %
Perez Zeledon	94.9[c]	37.3[c]	60.6[c]
Central plateau	100.0	3.2	29.0
Upala	88.8	44.4	59.0
Guanaguaste	44.7	44.7	20.8

a Totals may add to more than 100% where farmers use more than one system or to less than 100% where they use other systems (eg. mechanized).

b Includes only Brunca and Talamanca

c From Ballestero

Table 124. Agrochemical use by crop system, in southeast Guatemala for the 1984 spring planting as percentage of farmers.

	Bean monoculture	Maize + beans	Maize + beans + sorghum	Average
Use of fertilizer	83.3	77.3	80.0	80.2
Use of fungicides or insecticides	26.7	20.5	20.0	22.9

SOURCE: Survey

Table 125. Production problems most frequently mentioned by farmers, southeast Guatemala, 1984.

	Most frequent problem %	Problem in 1984 %
BGMV	39.4	11.7
Crysomelids	33.0	18.1
Slugs	27.7	7.5
Foliar diseases	14.9	9.6
Apion	10.6	3.2
Excess water	0	22.3

SOURCE: Survey

Table 126. Estimated expenditure and price elasticities of demand by income quartile, Brazil.

Income quartile	Expenditure elasticity	Price elasticity
High income	-.28	-.42
Quartile 2	.00	-.61
Quartile 3	.11	-.69
Low income	.19	-.76

SOURCE : Data from Fundacao Instituto Brasilero de Geografía y Estadística.

Table 127. Market shares of bean varieties, Medellin, Colombia, from 1983 wholesale and retail data.

Variety	Market share (%)	Grain type
Cargamanto	45.1	Large, cream with red mottles
Calima/Nima	27.4	Medium, red mottled
Uribe Rosado	11.6	Medium, pink mottled
Radical/Chocho	10.0	Medium, red
Imported Red	2.1	Small, red
Blanquillo	1.9	White
Others	1.9	Various

Table 128. Consumer attitudes toward bean characteristics by income group, Medellin, Colombia, 1984.

Characteristic	Low income consumer attitude	High income consumer attitude
Dark red broth	Strongly preferred	Acceptable
Light red broth	Rejected	Accepted
Short cooking time	Preferred	Indifferent
High water absorption	Preferred	Indifferent
Large seed size	Not preferred	Strongly preferred
Small seed size	Acceptable or preferred	Rejected
Price	Major consideration	Indifferent
Range of varieties purchased	Wide	Narrow

Table 129. Hedonic price functions for beans, Cali, 1983 according to weight, shape and color groups (Standard errors in parentheses).

Weight	0.266	0.266
	(0.010)	(0.009)
Shape	0.858	0.858
	(0.623)	(0.569)
Dark purple with white-mottles	0.082	-0.070
	(0.806)	(0.736)
Red with cream mottles	-0.623	-0.705
	(1.052)	(0.716)
Red	-1.644	-1.714
	(0.798)	(0.549)
Purple with cream mottles	1.626	1.557
	(0.853)	(0.726)
Cream with purple mottles	-5.766	-5.848
	(1.033)	(0.723)
Cream with red mottles	-4.007	-4.089
	(1.083)	(0.725)
Yellow with red mottles	-11.094	-11.165
	(1.033)	(0.763)
Price of Calima		0.557
Intercept	36.441	7.621
R^2	.61	.67

Table 130. Prices estimated from hedonic models for commercial and promising bean varieties, in Cali, Colombian Market, 1983. (Col$/kg).

Variety	Commercial price	Estimated price
Commercial		
Calima	98.4	100.0
Cargamanto	100.0	102.8
Mortiño	122.6	122.8
Red Imported	90.0	89.6
Promising		
BAT 1297		83.2
E 605		116.0
ICA L-23		96.0
ICA Llanogrande		94.6
La Selva 1		101.0

3. Biology and Control of Insect Pests.

Insect collection

A working collection of insects associated with the commodity under improvement is important to entomology especially in developing tropical countries. Insect taxonomy in the developing tropics is largely inadequate. Many of the key bean pest genera, such as *Empoasca*, *Apion* and many Chrysomelids, are not well identified. For these reasons a comprehensive bean insect collection is maintained at CIAT.

Apparently *Empoasca kraemeri* is not important in Argentina. Another species other than *Apion godmani* has been found in the Dominican Republic. *Trichoplusia ni* may be not as important as other Plusinid defoliators, such as *Pseudoplusia includens* and *Autoplusia egena*. Although a species of *Gargaphia* is important on beans in Brazil, it is not the same species which is common at CIAT. *E. kraemeri* seems to be the most important species of the genus in Cuba; and not *E. fabae*. A species of *Apion* of secondary importance in Guatemala apparently is undescribed.

Yield loss by Empoasca kraemeri

Two bean cultivars were subjected to known levels of attack of nymphs and adults of *E. kraemeri* for 14 day periods at different growth stages. On an average, Diacol-Calima and EMP 81 suffered a yield loss of 16.5 and 14.6 kg/ha, respectively, per insect/leaf per 14 day period.

Insects attacking fruiting structures

A study of the insect complex attacking the reproductive structures of beans was conducted at Palmira. Some of the interesting findings were that *Cydia fabivora* Meyrick and *Epinotia aporema* Walsingham attack physiologically mature pods. *Strymon melinus* (Hubner) was found perforating pods, and its damage was indistinguishable from that of *Heliothis virescens* (Fabricius).

Slug biology

Under the mean temperature conditions at CIAT (24°C) the slug *Vaginulus plebeius* was found to lay eggs in coiled strings with an average 23.7 eggs per batch. The egg stage lasted 31.4 days. Newly hatched slugs weighed 0.05 g and reached a mean weight of 3.8 g in slightly over four months before the first eggs were laid.

The longer food was witheld from a slug (up to seven days) the less it ate during a 24 hr period after starvation (17.5 cm^2 of leaf area with two days of starvation, significantly different at 5% level from 12.7 cm^2 after seven day fast).

Having 1, 2 or 4 specimens of this gregarious pest feeding together did not affect the amount of leaf area consumed per slug.

Slugs that were raised in shallow petri dishes where they could not burrow required 23 months to reach maturity, whereas those raised in 10 cm deep trays reached maturity in over four months.

Biology of *Zabrotes subfasciatus* on beans

In 1981 the biology of *Z. subfasciatus* on susceptible and resistant beans was reported. This year some aspects on the effect of resistance on oviposition of the succeeding generation are reported.

Colonies of *Z. subfasciatus* were established on the following bean lines : Diacol-Calima (susceptible), G 12942 (intermediate) and G 12953 (resistant). Progeny from the colonies were placed on the three lines in the combinations given in Table 131.

The mean number of eggs laid per female depended upon the source accession for the female as well as the accession it was placed on. For example, over twice as many eggs were laid on G 12953 from females raised on Diacol-Calima than females raised on G 12953 (Table 147). A significant, but less marked, reaction was noted for G 12942. The ability of males raised on G 12953 or G 12942 to fertilize eggs was equal when measured in oviposition or mortality. Significantly, a higher percentage mortality was found in progeny of pairs raised on Diacol-Calima and placed on G 12953 than in pairs raised on G 12953 and placed on the same.

Table 131. Effect of bean accessions on oviposition and mortality of *Zabrotes subfasciatus*.

Source of *Z. subfasciatus*[a] Female	Male	Placed on	Mean number of eggs laid	Percentage mortality from egg to adult
D Calima	D Calima	D Calima	53 a*	8 c
D Calima	D Calima	G 12953	36 c	84 a
D Calima	D Calima	G 12942	50 ab	22 c
G 12953	G 12953	D Calima	18 de	9 c
G 12953	G 12953	G 12953	16 e	73 b
G 12942	G 12942	D Calima	39 c	7 c
G 12942	G 12942	G 12942	37 c	20 c
D Calima	G 12953	D Calima	56 a	4 c
G 12953	D Calima	D Calima	24 d	1 c
D Calima	G 12942	D Calima	50 ab	5 c
G 12942	D Calima	D Calima	42 bc	4 c

[a] Diacol-Calima (susceptible); G 12953 (resistant); G 12942 (intermediate).

* Figures in the same column followed by the same letter(s) are not significantly different at $p = 0.05$ of the Duncan Multiple Range Test.

III. Scientific Training and Network Activities

1. Scientific Training

Introduction

As a result of the collaboration between the CIAT Bean Program and national institutions for the purpose of obtaining improved lines, bean scientific training continued to support the efforts of researchers particularly with respect to the training of technicians in the evaluation of promising germplasm.

As for scientific training outside the CIAT headquarters, greater emphasis was given to the study of the limiting factors on crop production at the national and local level, and also on the development of skills in the diagnosis and treatment of problems. The support given to the training of 102 professionals (Table 132), through five courses carried out in Peru, Guatemala, Panama, Cuba and Colombia, reflects this common goal of researchers in CIAT and the national institutions.

With this same goal the XI edition of the Intensive Multidisciplinary Phase on Bean Production Research was carried out over six weeks with the participation of 25 visiting researchers from: Colombia (8); Guatemala (2); Peru (3); Mexico (3); Costa Rica (30); Ecuador (2); Dominican Republic (2) and Haiti (2). Seventeen of these professionals continued their training in the specialization phase in different disciplines, particularly in on-farm research and bean production systems which were offered to 12 professionals.

The advances achieved by the program researchers in collaboration with national institutions, with respect to production of improved lines defined more precisely the objectives and activities of these courses. The principal objective was the development of management skills for these new promising genetic lines, by carrying out experiments, particularly at the farm level.

As in 1983, this year's participants in courses held in Colombia, Peru and Panama received seed and the corresponding material to carry out trials of advanced lines in their respective work sites. Thus, the network of collaborating technicians from the respective national program is reinforced, a network which receives as a consequence of the course the responsibility not only of evaluating the new lines but also of making them available to farmers.

Achievements

The efforts of the bean scientific training at headquarters and in the different countries has:

(1) Contributed to the development of scientific leadership in the national institutions through support of research work for academic degrees such as PhD and MS degrees. This contribution guarantees continuity of the work and stimulates collaborative and independent research. Figure 15 describes the evolution of this contribution.

(2) Transference and adaptation to local situations of a methodology for the organization and conduction of intensive courses on the crop. For example, the Centro Nacional de Pesquisa em Arroz e Feijao (CNPAF) in Brazil carried out this year the III course on bean research and production without the collaboration of CIAT. The report of this III course indicated that due to the experience acquired from the first two courses, this III course could be carried out with national resources alone. Also, in Colombia, a regional institution, the Corporacion Autonoma Regional del Valle del Cauca (CVC) carries out with its own technicians trained at CIAT training activities such as bean production courses for mid-level technicians, with minimum of support from CIAT.

(3) Decentralization of training activities through greater support and a greater number of in-country courses. This is closely interrelated with the release of new varieties in the countries since one of the principal objectives of these courses is the recognition and availability of these new varieties. The number and quality of those professionals which have been previously trained and the availability of a great number of audiotutorials have made these courses possible. Figure16 and Table 133 give the number of participants in these courses, the countries and location of these courses.

(4) To support the organization and production of in-country courses having an international character. In this sense, Costa Rica and Guatemala have had successful experiences. Professionals previously trained at CIAT participate actively in the development of courses for their countries.

(5) Evaluation of nurseries at the local level which formerly were only evaluated at CIAT. Training in management of these nurseries has resulted in the selection of promising germplasm in the initial stages within a country.

Training at CIAT

Table 134 shows the number of professionals trained and the man/months corresponding to each. A total of 72 professionals participated in training activities. At the country level, the U.S.A., Mexico and Peru had the greatest number of man/months of training.

Table 135 describes the situation for those professionals trained by discipline and training category. Six visiting researchers carried out work for a PhD and three for an MS degree. Training was concentrated in phytopathology (102.5 man/months of a total of 275). Noteworthy is the emphasis given to on-farm research and bean cropping systems (35.2 man/months). For the first time, 12 visiting researchers concentrated their work of seven weeks on the planning, execution and analysis of on-farm research.

In-country courses

In addition to the XI intensive multidisciplinary phase for bean production research, in-country courses were carried out in Colombia, Peru, Guatemala, Cuba and Panama. A total of 102 professionals participated in these activities (Table 132). The course in Guatemala had an international character since 18 professionals participated from Guatemala, three from Costa Rica, two from Panama, two from El Salvador and two from Honduras.

Table 133 shows that support was given to a total of 20 in-country courses. In Colombia 11 courses were carried out in collaboration with the CVC.

Workshops

Three workshops were held in 1984 with the participation of 130 persons. See Table 136. An important component of these workshops was the field work which resulted in the interchange of criteria on the selection of promising materials in the field. Two additional points on the workshop on the International Yield Trials in beans were : (1) discussion on the standard evaluation system for beans; and (2) the discussion on plant development stages. The objective of the standard evaluation system is to unify the evaluation scales of the principle crop problems. The evaluation system is the one which the CIAT Bean Program will use in all its international nurseries.

Table 137 lists the visiting researchers trained by CIAT during 1984.

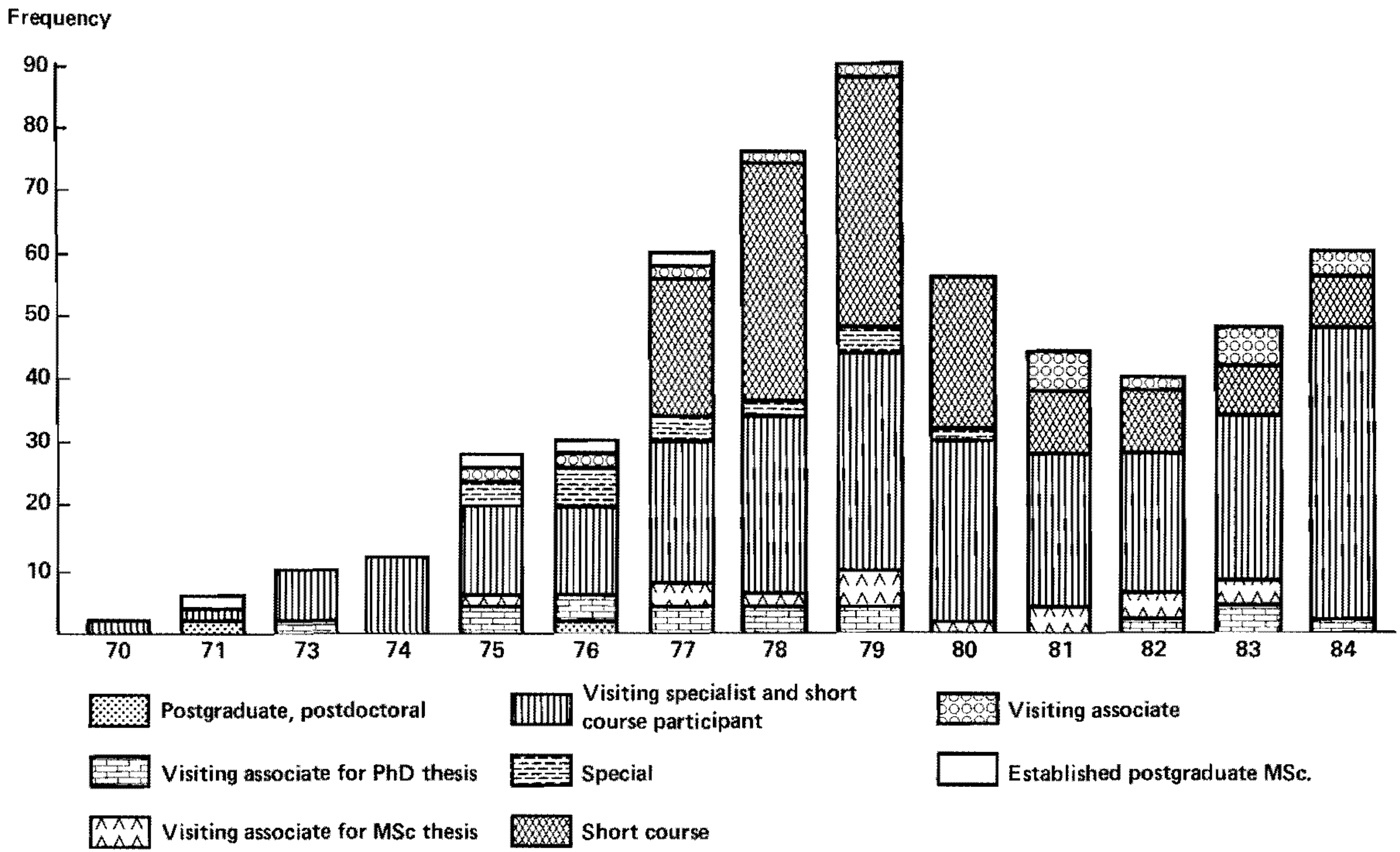


Figure 15. Visiting researchers by year and training category for 1970-84.

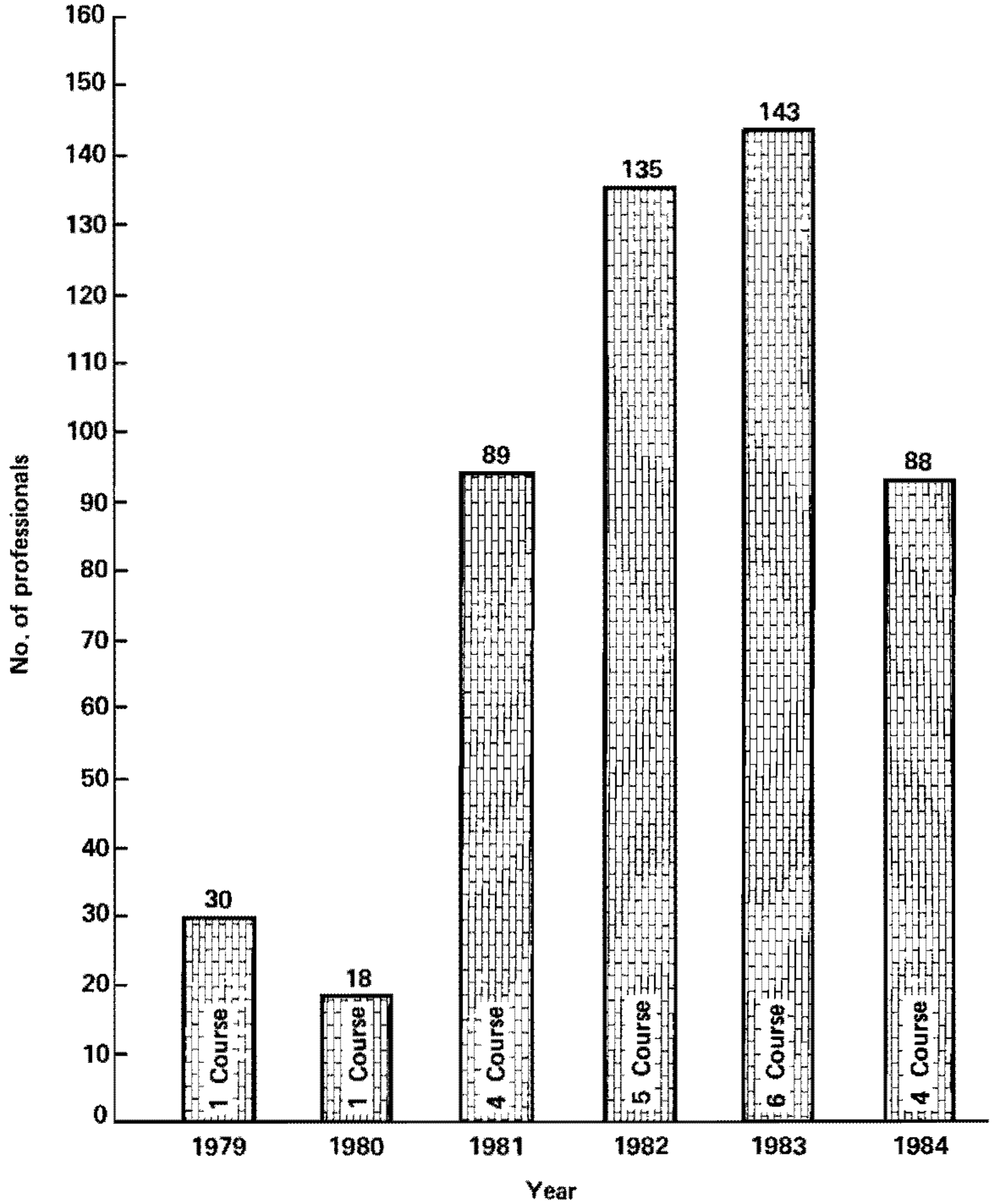


Figure 16. Number of professionals trained in in-country courses.

Table 132. In-country courses.

Country	Institution	No. of participants
Colombia	Fedecafe, CVC	14
Peru	INIPA	26
Guatemala	ICTA	28
Cuba	Ministry of Agriculture	20
Panama	IDIAP	14
	Subtotal.........	102
Colombia	CIAT, XI intensive phase	25
	TOTAL	127

Table 133. List of in-country courses.

Country	Year	Duration (weeks)	Participants	Collaborating institutions
Honduras	1979	3	30	Secretariat of National Resources
Cuba	1980	1.5	18	Ministry of Agriculture
Cuba	1981	2	24	Ministry of Agriculture
Nicaragua	1981	2	19	MIDINRA
Peru	1981	2	27	INIPA
Chile	1981	2	19	INIA
Cuba	1982	2	26	Ministry of Agriculture
Brazil	1982	3	28	EMBRAPA
Costa Rica	1982	2	27	MAG, FAC, Univ. of Costa Rica
Guatemala	1982	2	25	ICTA, DIGESA
Honduras	1982	2	29	Secretariat National Resoyrces
Cuba	1983	2	31	Ministry of Agriculture
Brazil	1983	3	26	EMBRAPA
Costa Rica	1983	2	28	MAG, FAO, Univ. of Costa Rica
Dominican Republic	1983	2	29	Secretariat of State for Agriculture
Honduras	1983	2	29	Secretariat of Natural Resources
Peru	1984	2	26	INIPA
Guatemala	1984	2	28	ICTA
Cuba	1984	2	20	Ministry of Agriculture
Panama	1984	2	14	IDIAP

Table 134. List of professionals trained by country and training category, number of professionals (No.) and man/months (M/M) in 1984.

Country	Visitor by special invitation										Visitor by special invitation					
	PhD thesis		MS thesis		Speciali-zation		Short course participant		Short Course		Associate		Postgraduate student		TOTAL	
	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M
Argentina					3	6.2									3	6.2
Brazil			1	12.1							2	0.9			3	13.0
Chile					1	3.5									1	3.5
Colombia					1	1.0	3	8.9	5	6.6					9	16.5
Costa Rica					2	3.9	2	11.2	1	1.3					5	16.4
Cuba			1	9.1	1	3.7									2	12.8
Dominican Rep.					5	9.5			2	3.0					7	12.6
Ecuador							2	8.3							2	8.3
El Salvador			1	5.0											1	5.0
Guatemala					2	2.8	2	5.9					1	12.0	5	20.7
Haiti							2	10.1							2	10.1
Honduras					1	0.4									1	0.4
Mexico					4	14.9	3	10.3							7	25.2
Nicaragua					1	0.9									1	0.9
Panama					1	3.9									1	3.9
Peru	1	3.0			3	8.4	3	11.2							7	22.6
U.S.A.	4	33.2													4	33.2
Belgium													2	15.7	2	15.7
West Germany	1	9.4													1	9.4
Holland					1	12.1									1	12.1
Turkey					1	0.7									1	0.7
Kenya					1	3.9									1	3.9
Tanzania					1	5.2									1	5.2
Uganda					2	9.4									2	9.4
Rwanda					1	3.5									1	3.5
Burundi					1	3.5									1	3.5
TOTAL	6	45.6	3	26.2	33	97.4	17	65.9	8	10.9	4	16.6	1	12.0	72	275

Table 135. Professionals trained listed by country and training category, number of professionals (No.) and man/months (M/M) in 1984.

Discipline	Visitor by special invitation										Visitor by special invitation					
	PhD thesis		MS thesis		Speciali-zation		Short course participant		Short Course		Associate		Postgraduate student		TOTAL	
	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M	No.	M/M
Agronomy					5	15.5	2	10.6							7	26.1
Economy					3	15.2									3	15.2
Entomology	1	8.6					2	8.8			2	0.9			5	18.4
Breeding	3	18.0	2	14.1	13	31.1	3	11.6			2	15.7	1	12.0	22	85.5
Phytopathology					4	10.1	1	5.2							5	15.3
Phytophysiology			1	12.1	1	1.9									2	14.0
Seeds	1	12.1			1	3.9									2	16.0
Microbiology	1	6.9													1	6.9
Farm systems					3	5.4	9	29.8							12	35.2
Production Management									8	10.9					8	10.9
Genetic resources			2	12.6											2	12.6
Phytovirology					1	2.0									1	2.0
TOTAL	6	45.6	3	26.2	33	97.7	17	66.0	8	10.9	4	16.6	1	12.0	72	275

Table 136. Workshops held in 1984

Date	Theme	No. of participants
March 25 - April 6	Improved resistance to the bean golden mosaic virus (BGMV) in CNPAF, Brazil.	13
November 26 - 29	International bean trials, in CIAT	70
November 30 - December 4	Bean breeding, in CIAT	47

Table 137. List of visiting researchers trained in beans during 1984.

	ARGENTINA		
1.	Salgado Marcelo	INTA	Phytopathology
2.	Gargiulo Carlos A.	Est. Exp. Obispo Colombres	Economics
3.	Zamudio Néstor	Est. Exp. Obispo Colombres	Breeding
	BRASIL		
4.	Martínez Sueli	IAPAR	Entomology
5.	Yokoyama Massaru	EMBRAPA	Entomology
6.	Sponchiado Baltazar	EMPASC	Phytophysiology
	CHILE		
7.	France Rene A.	INIA	Phytopathology
	COLOMBIA		
8.	Suárez Carlos E.	ICA	Breeding
9.	Pulido José I.	ICA	Production
10.	Andrade Gustavo	CVC	Production
11.	Beltrán Jorge A.	CIAT	Production
12.	Arrieta Juan M.	ICA	Production
13.	Vallejo Raúl	ICA	Farm systems
14.	García Alvaro	ICA	Farm systems
15.	Sierra Luis J.	ICA	Farm systems
16.	Santacruz Diego	CIAT	Production
	COSTA RICA		
17.	Bonilla Gonzalo	U. de Costa Rica	Phytopathology
18.	Gamboa Claudio	U. de Costa Rica	Production

19.	Corella José F.	Min. de Agric. y Ganadería	Farm systems
20.	Hernández Germán	Consejo Nal. de Producción	Agronomy
21.	Montes Luis	Min. de Agric. y Ganadería	Farm systems

CUBA

22.	Barreiro Lorenzo	Min. de Agricultura	Agronomy
23.	Faure Benito	Min. de Agricultura	Breeding

R. DOMINICANA

24.	Ramírez Carlos J.	S. de Estado de Agricultura	Agronomy
25.	Oviedo Fernando	S. de Estado de Agricultura	Agronomy
26.	Peña Matos Estela	S. de Estado de Agricultura	Phytopathology
27.	Morales Milton	S. de Estado de Agricultura	Phytovirology
28.	Guerrero Joaquín	S. de Estado de Agricultura	Production
29.	Flórez José M.	S. de Estado de Agricultura	Agronomy
30.	Martínez Rafael	S. de Estado de Agricultura	Farm systems

ECUADOR

31.	Linzan José L.	INIAP	Agronomy
32.	Unda José R.	INIAP	Farm systems

EL SALVADOR

33.	García Carlos M.	CENTA	Breeding

GUATEMALA

34.	Viana Ruano Abelardo	ICTA	Economics
35.	Soto Juan J.	ICTA	Genetic resource management
36.	Miranda Oscar	ICTA	Farm systems
37.	Pérez Ovidio	ICTA	Farm systems
38.	Rodríguez	ICTA	Breeding

HAITI

39.	Fils-Aime Marie Mona	Ministerio de Agricultura	Breeding
40.	Previllon Gabrielle	Ministerio de Agricultura	Entomology

HONDURAS

41.	Echeverría José	Ministerio Rec. Naturales	Breeding

MEXICO

42.	González Carlos	INIA	Breeding
43.	Salinas Rafael	INIA	Breeding
44.	García Martha	SINAP	Genetic resource management
45.	Montes Roberto	INIA	Breeding
46.	Rodríguez Mario	INIA	Breeding
47.	Arcos Gerardo	INIA	Entomology
48.	Ledesma Luis	INIA	Breeding

NICARAGUA

49.	Pérez Telva	MIDINRA	Breeding

PANAMA

50.	De García Rubén	IDIAP	Agronomy

PERU

51.	Guerra Luis	INIPA	Phytophysiology
52.	Guillen Dante	INIPA	Agronomy
53.	Sandoval Alberto	IVITA	Farm systems
54.	Bruno Heine José	IVITA	Breeding
55.	Gamaría Mirihan	IVITA	Phytopathology
56.	Venero Roger	IVITA	Farm systems

57.	Rojas Elmer	IVITA	Farm systems

ESTADOS UNIDOS

58.	Barkdoll Anne	U. de Florida	Microbiology
59.	Kornegay Julia	U. de Cornell	Entomology
60.	McElroy Jeffrey	U. de Cornell	Breeding
61.	Dale Wilson	U. de Ohio	Seeds

BELGICA

62.	Schmit Verónica	U. Nacional de Gembloux	Breeding
63.	Lewinson Elizabeth	U. Nacional de Gembloux	Breeding

ALEMANIA

64.	Panse Axel	U. Friedrich Wilhem	Breeding

HOLANDA

65.	Van Herpen Catharina	U. de Wageningen	Economics

TURQUIA

66.	Sakar Dogan	Inst Zarai Arastirma	Breeding

KENYA

67.	Muchiri Johnson	Ministerio de Agricultura	Seeds

TANZANIA

68.	Rwiza Elisabeth	Taro	Breeding

UGANDA

69.	Oree Amos	Ministerio de Agricultura	Breeding
70.	Sophy Musaana	Ministerio de Agricultura	Breeding
	RWANDA		
71.	Enoch Rubaduka	Fund. Iyamulemyeusar	Breeding
	BURUNDI		
72.	Isidore Nzimenya	I.S.A.B.U.	Breeding

2. Central America and the Caribbean

The Swiss Development Corporation (SDC)-funded Central American project continues to generate and transfer technology and train personnel of national programs. It stresses a collaborative network among participating countries. The Interamerican Institute for Cooperation on Agriculture (IICA) and the Instituto de Ciencia y Tecnología Agrícola (ICTA) have continued to provide the logistic support for project operations, for the scientist located in Costa Rica and the two scientists in Guatemala, respectively.

Highlights of achievements in 1984. During 1984, a consultation meeting was held in Nicaragua during the PCCMCA meeting to coordinate research and training activities of the participating countries. Two workshops were held during the year, one in Costa Rica to review progress and problems of on-farm research, and a second on the standardization of evaluation for web blight. Two in-country courses were held, in Panama and Cuba. Participants from Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama and the Dominican Republic attended a regional course in Guatemala which was held in collaboration with ICTA.

On-farm trials were extended which included cultural practices to increase and stabilize the yield of recently released varieties. Improved tolerance to web blight was observed in lines derived from some less tolerant parents which suggests transgressive segregation. For the first time Azufrado and Canario lines were observed to be highly tolerant of the BGMV virus. Earliness and/or resistance to bacterial blight, web blight, or rust was found in black BGMV tolerant lines.

The adaptation nursery of red, black and red-mottled grain types continued to provide materials superior to the newly released varieties. The national programs have established a uniform preliminary yield trial per country in several locations.

Large amounts of foundation seed of the newly released varieties were provided to the Dominican Republic, Cuba and Costa Rica.

Research activities Bean pod weevil. In 1984, the International Apion Nursery was planted in Mexico, El Salvador, Guatemala and Honduras. Thirteen breeding lines (black or red-seeded) were distributed, as well as promising germplasm accessions of Mexican origin. The new breeding lines represented modest gains both in resistance levels and adaptation. The black-seeded lines APN 91, 92 and 93 were well adapted and more resistant than either parent. These represent additional evidence for transgressive segregation for *Apion* resistance.

Resistance was confirmed in 14 of the germplasm accessions identified last year as promising (Table 138). Of these, G 3317 and G 13614 are moderately well-adapted, and the latter has a commercial red grain type.

Many important commercial cultivars were also included in the nursery to evaluate known materials. All commercial cultivars were highly susceptible with the exception of Tamazulapa, which was known to be intermediately resistant. In 1984, 1000 Mexican germplasm accessions were evaluated.

Bean golden mosaic virus (BGMV). In 1984, early maturing black seeded lines selected in Guatemala were tested in on-farm trials. The most common objection to the BGMV resistant ICTA varieties has been their lateness. The new lines were derived by backcrossing early lines with ICTA Tamazulapa. Most significant has been the identification of lines for the Caribbean with red-mottled seed and levels of tolerance comparable to ICTA-Quetzal.

A limited number of F_5 families from interspecific (*P. vulgaris* x *P. coccineus*) crosses were screened. One of these offered a good level of resistance, and may be incorporated into the breeding program.

Several lines with Brazilian and Argentinian grain types were screened in Guatemala. Of these 557 lines, several showed promising levels of resistance.

Collaboration increased this year with INIA in Sinaloa and Veracruz, Mexico. Lines from the Mexican breeding program were planted in Guatemala to compare BGMV reactions with those obtained in Mexico. Lines from Veracruz performed well while materials from Sinaloa were variable, due to poor adaptation.

Web blight. This is the most important and destructive fungal disease of beans in Central America for which an integrated control scheme is necessary in which varietal resistance plays an important role. And while Costa Rican scientists have recognized the superior resistance of the cultivars Porrillo 70, Talamanca and Negro Huasteco 81, the resistance of a new breeding line, HT7716-CB (H8)-18-CM-M, was confirmed as superior to that of Porrillo 70. The new line yielded from 51 to 93% more than Porrillo 70 under disease pressure in different cultivation systems.

Additionally, eight more promising lines were identified which seem superior to Porrillo 70. Lines and populations sent from CIAT were also screened and 20 families and 300 individual plants were selected. Outstanding were : NADC 9413-16, NHDC 9412-2, HT 7687-1, HT7700-1, HT 7694-6, Esparza 17, Esparza 20 and HT 7694-12.

The International Web Blight Nursery has provided valuable data for the selection of parents. Increasing levels of resistance may be possible as several of the promising sources of resistance are unrelated genetically, and offer the possibility of recombining resistance genes.

VIM, the International Web Blight Nursery. The VIM in 1984 with 100 entries not only contained potentially tolerant parents but also contained advanced lines to be evaluated for tolerance and adaptation. Thirty entries were eliminated. The most tolerant entries were ICTA L-883-2M, RAB 34, RAB 58, RAB 64, BAT 160, BAT 1449, DOR 198, XAN 33, and XAN 90. All of these were superior to Talamanca, Porrillo 70 and Negro Huasteco 81, the tolerant checks.

In the VP (Preliminary Nursery, selections from the VA), two lines were highly tolerant : NAG 12 and RAO 27, which were also the two best in the 1983 VA (Adaptation Nursery). In the VA/84 many lines had excellent tolerance. Interestingly, among the black lines about half were progeny of common bacterial blight resistant lines, suggesting that sources of *Xanthomonas* tolerance are contributing genes for resistance to web blight.

Besides varietal tolerance other control measures were studied to improve an integrated control scheme. A cheaper fungicide, Duter, worked as well as benomyl. Also, the association of maize/beans reduced the severity of the disease as well as by crop rotation with maize.

Control of slugs. In some areas where heavy infestations of slugs were observed, farmers clean the field previous to planting by removing crop residues. Farmers open trenchs around the field and apply an insecticide such as Sevin or Aldrin.

The use of Sevin (85 p.s) or Dipterex (80 p.s.) in a commercial dosage sprayed during the night has produced efficient control when the presence of the slugs was detected opportunely.

Cooking quality. Most national programs analyze cooking quality at some point in the process of varietal release, although cooking quality is not an important selection criterion. However, Rojo 70 in El Salvador is an exception. Rojo 70 was adopted as a variety in 1970, and was widely accepted by farmers for its high yield potential, but in recent years it has been rejected because of long cooking time. A small project has been initiated to improve the quality of Rojo 70 through crossing with the collaboration of INCAP and the University of Costa Rica.

Adaptation Nursery. The Adaptation Nursery has been received by national programs with more enthusiasm than any other nursery distributed by CIAT, due to the wide genetic variability offered, and the improved seed color of red grain types. The primary purpose of the Adaptation Nursery is an agronomic evaluation of a large number of breeding lines in a simple, unreplicated nursery. In the 1984 VA nurseries, 145 black-seeded lines were distributed to Costa Rica, El Salvador and Guatemala. The red-seeded nursery with 220 new entries was distributed to Costa Rica, Nicaragua, Honduras, El Salvador and Guatemala.

Data from the Adaptation Nursery include a yield estimate, as well as reaction to the important diseases - web blight, BGMV, and rust. In Guatemala, which has an active crossing program, the Adaptation Nursery is mostly a source of parental material instead of new varieties.

The adaptation nurseries with mottled grain types have provided new adapted materials with commercial grain size, shape and color for the Dominican Republic, Haiti, Cuba and Panama.

Preliminary Nursery. In the annual meeting of the PCCMCA (Cooperative Central American Program for the Improvement of Food Crops), national program participants developed a scheme of follow-up testing for lines selected from the Adaptation Nursery. It is not possible nor necessarily desirable to implement a uniform testing scheme in all countries but most programs employ some variation of the Preliminary Nursery, which is a simple national program version of the Adaptation Nursery planted in the various regions of each country prior to yield trials. The nursery is uniform within each country but not between countries. The Preliminary Nursery is normally planted in three or four sites in each country, with two repetitions per site. One row plots are used and yield is estimated.

Nicaragua and Honduras have been particularly successful in doing Preliminary Trials. In Honduras, four lines from 1983 are being tested in large "confirmation plots" in El Paraiso Province. This represents more rapid progress than expected.

In Costa Rica, web blight resistance is the overriding factor in the selection of materials for advanced testing. Two lines are promising for their resistance: NAG 12 (black) and RAO 27 (red).

Investigations in the "Tapado" planting system. Preliminary results have suggested that improved varieties might increase yields in this planting system, in which farmers scatter seed in tall weeds and chop these down to form a mulch.

Studies were initiated to develop a methodology for evaluating genotypes in the "tapado" system. Criollo varieties were generally better adapted and more competitive with weeds and more rust resistant than the improved bush beans. These findings indicate that, it may be useful to experiment with improved climbing beans, which are more aggressive than bush beans.

The studies also revealed that seedling emergence in tapado is poor, frequently around 50%.

Planning and Selection of Crosses with National Programs

During 1984, national program breeders became more involved in the planning of crosses to be made in CIAT. Efforts were made to plant and select F_2 populations in every country. At present, the programs in Guatemala, El Salvador and Costa Rica have ample experience in selecting in segregating populations.

3. Technology Transfer

From CIAT to national programs. The national programs continued to receive training in the selection of superior germplasm, in participation in workshops or regional meetings, the establishment of on-farm trials, and in-country or regional courses.

During the year, several nurseries were sent from CIAT to the region which included early and advanced progenies, adaptation nurseries, VEF, and specific nurseries for bean golden mosaic virus (BGMV), web blight, angular leaf spot, Ascochyta, anthracnose, rust, common bacterial blight and Apion. During the year, 36 sets of the International Bean Yield and Adaptation Nurseries (IBYAN), bush and climbing types, were distributed in Central America. Only requested nurseries are distributed) on-farm trials were established in Costa Rica, Guatemala and Honduras using promising new lines, in combination with different cultural practices, and cropping systems.

The increase in the capability of the national programs to manage and select germplasm from early generations made it possible to plant large numbers of F_3, F_4, etc. progenies to select in situ for adaptation and local problems. A great number of crosses planned specifically with each country were planted.

Among national programs. Nurseries. A substantial increase in the number of local yield nurseries (VINAR) were planted.

A total of 67 VICAR (Vivero Centroamericano de Adaptación y Rendimiento) nurseries were distributed to Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, the Dominican Republic, Cuba and Puerto Rico. The VICAR included the best materials of the IBYAN, VIM and VINAR of each country. The best red lines were XAN 90, BAT 1217 and BAT 1449, and the best black lines were ICTA 81-64, ICTA 81-31, ICTA L 883-2-M, and XAN 87, and XAN 93 from CIAT (Tables 139-144).

Agronomy - On Farm Trials

Dominican Republic. The on-farm trials planted in several locations revealed the superiority of the lines DO-198 and BAT 1412 over the local varieties Pompadour Checa, Jose Beta, and Constanza. The lines yielded well even under high pressure of the whitefly Aleurodes trialeurodes. The trials included chemical weed control and fertilization comparisons. The use of chemical control increased yields by 25% and fertilization by 25%. The new lines yielded 10-25% better than the local varieties. The two lines being increased will be released in 1985. (see Tables 145-147).

On-farm trials were also planted in Costa Rica including some in the "tapado system". In Guatemala and Honduras, the number of trials were substantialy increased.

Seed multiplication. The project has helped the national programs increase seed for the national and regional nurseries and for promising lines.

Training. Scientists from Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Cuba, Dominican Republic and Haiti participated either at CIAT headquarters or in Central America bean courses or specialized training.

In-country courses were organized in Cuba, Panama and Guatemala. The latter was of a regional character, and was carried out in collaboration with the Guatemalan national program. Around 100 participants attended these courses which emphasized technology transfer and on-farm research.

Two candidates for M.Sc. continued their graduate studies, one from El Salvador and one from Guatemala.

The project sponsored visits of national program scientists to other countries to exchange knowledge, to standardize methodology and evaluation scales. Emphasis was given to the following regional projects Apion, BGMV, and web blight.

A national workshop was held in Costa Rica to the review progress and problems in on-farm research carried out during the past two years. Most of the participants indicated that the on-farm trials in the Zeledon region helped in the rapid adoption of the new varieties by farmers. However, they agreed to make the trials simpler and smaller, and increase their number.

A regional workshop was also held in Costa Rica to standardize the scale to evaluate materials for web blight.

Regional coordination meeting. During the PCCMCA meeting held in Managua, Nicaragua, April 30-May 4, a meeting took place with the coordinators of the national programs involved in the project. In addition, the national scientists, members of the CIAT staff, the project scientists, and a representative of SDC attended the meeting. Regional research activities were discussed taking into account the comparative advantages offered by each country. The need for additional germplasm from CIAT; for training or economic impact studies were discussed. A similar meeting was held with the coordinators during the International Trial Workshop, at CIAT mainly to discuss the financing of some projects with regional impact.

A substantial improvement in the work relationships with the different Title XII projects occurred during the year, particularly in Guatemala, Honduras, and Dominican Republic. The coordinator and a CIAT breeder participated in several planning meetings with the Universities of Nebraska, Puerto Rico and Cornell as well as in field work, reviewing the materials planted in the U.S.A. and Puerto Rico by the national programs from these institutions.

Table 138. Accessions of germplasm of Mexican origin with resistance to the bean pod weevil, *Apion godmani*.

Accession number	Identification	% grain damaged
603362	Aguas Calientes 40	39
03313	Puebla B-1	24
03317	Puebla 22	32
03324	Puebla 36	23
03325	Puebla 36-1	24
03336	Puebla 49	40
03315	Puebla 14-A2	38
03530	Zacatecas 58	24
03578	Hidalgo 46 A	24
03585	Queretero 21	33
04397	Tlaxcala 76	36
08142	Amarillo 169	37
13602	Pinto	38
13614	De Celaya	28
05896	Bayo Mex[a]	90
	Tamazulapa[b]	74

a Susceptible variety

b Variety with intermediate resistance

Table 139. VICAR (red-seeded) 1983A. Summary of average yields in kg/ha, standard deviations, coefficients of variation, minimun significant differences at the .05 level and relationship in percentage yield over Rojo de Seda.

Identification	Nicaragua	El Salvador	Honduras			Costa Rica			%
	Carazo	San Andres	Sn.Francisco del Valle		Villa Ahumada	E.E.F.B. Alajuela	Perez Zeledon	$\bar{X}$	over Rojo de Seda
Coricibi	1941	594	2331	2747	1768	1676	173	1872	38
Chorotega	1504	480	2303	2625	2036	1551	213	1785	31
Revolucion 81	1867	1156	1663	1883	1797	2103	151	1770	30
Revolucion 79	1456	569	2233	2392	1583	2196	187	1769	30
BAT 789	1724	388	2099	2243	1906	1839	133	1722	27
Acacias 4	1487	523	1729	1875	2322	1770	136	1640	21
Dor 164	1220	255	1985	2101	1968	2049	216	1632	20
Centa Izalco	1225	816	1989	2193	1471	1880	213	1631	20
Huetar	985	441	2022	2110	1926	2072	178	1622	19
Local Checks	1439	1161	1604	1769	1574	1956	147	1608	18
Honduras 46	861	906	1580	1801	2204	1555	191	1516	11
Rojo de Seda	980	496	1404	1503	2069	1569	138	1360	
$\bar{X}$ =	1390.75	648.78	1911.83	2103.83	1885.25	1850.75	173.00		
S =	103.57	184.59	448.83	513.55	283.16	123.38	39.33		
CV % =	7.45	28.45	23.47	24.42	15.01	6.67	22.74		
DMS.05 =	175.38	312.58	760.06	869.65	479.51	208.94	66.62		

Table 140. VICAR (red-seeded) 1984/A. Summary of average yields in Kg/ha. Standard deviations, coefficients of variation, D.M.S at .05 and percentage yield over Zamorano.

Identification	Guatemala Jutiapa	Guatemala Cuyuta	El Salvador San Andres	El Salvador Ahuachapan	Honduras Zamorano	$\bar{X}$	% over Zamorano
Revolución	2248	1135	1818	1641	1606	1690	114
Xan 90	1826	1070	1554	1807	1899	1631	107
Honduras 46	2034	1402	1738	1588	1356	1624	106
Bat 1217	1932	1185	1495	1762	1430	1561	98
Centa Izalco	2136	1137	1754	1449	1099	1515	92
Local check	2144	867	1762	1780	993	1509	91
Acacias 4	1836	829	1599	1641	1556	1492	89
BAT 1449	1754	870	1380	1383	1735	1424	80
BAT 789	1960	1079	1509	1180	1391	1424	80
Revolucion 79	1943	847	1700	1294	1236	1404	78
Corobici	2053	1041	1216	1260	1100	1334	69
Huetar	1814	885	1316	1420	1246	1336	69
Xan 33	1294	359	812	1387	2060	1182	50
Mcd 257	1709	30	524	978	714	791	--
Zamorano	1599	227	323	959	839	789	--
$\bar{X}$	1895	855	1361	1425	1340		
S	409	166.2	122	359	180		
CV%	21.6	19.4	15.5	25.2	21.0		
DMS .05	682	95.9	122.3	208	161.6		

Table 141. VICAR (black-seeded) 1983A. Summary of average yields in kg/ha, standard deviations, coeficients of variation, minimum significant differences at the .05 level and percentage yield over the local checks.

	Nicaragua	Guatemala		El Salvador	Honduras		Costa Rica			
Identification	Carazo	Jutiapa	Chimal-tenango	San Andres	Sn.Francisco del valle	Villa Ahumada	Perez Zeledon	E.E.F.B. Alajuela	X	% OVER LOCAL CHECKS
ICTA TAMAZULAPA	1669	1924	1448	759	2041	1577	201	1572	1339	26
TALAMANCA	1422	2101	1365	1090	1430	1918	245	1444	1377	24
D 145 3/4 + COMP.1 1/4	1827	1882	1398	527	1486	1472	320	1584	1312	18
BRUNCA	1644	1556	1353	815	1744	1184	299	1615	1276	15
PORRILLO SINTETICO	1865	1868	1345	776	1191	1320	278	1545	1231	14
NEGRO HUASTECO 81 (D145)	1601	1871	1415	608	1467	1431	249	1452	1262	13
D145 1/4 + COMP. 1 3/4	1400	1683	1330	774	1389	1413	309	1679	1247	12
COMPUESTO 1	1493	1821	1198	710	1390	1420	274	1535	1230	10
D145 1/2 + COMP. 1 1/2	1501	1887	1175	506	1387	1422	305	1589	1221	10
ICTA QUETZAL	1499	1423	1243	669	1717	1244	300	1625	1215	9
ICTA 81-64	1233	1567	1098	605	1610	1479	263	1536	1173	5
TURTURIALBA-1	1359	1931	1198	808	1130	1183	199	1311	1139	2
ICA PIJAO	1694	1760	918	460	1220	1347	163	1484	1130	--
ICTA JUTIAPAN	1345	1506	1062	556	1496	1399	236	1339	1117	--
LOCAL CHECKS	1651	1349	1803	253	1407	1182	377	1110	1114	--
CENTA TAZUMAL	1806	1354	803	581	1300	1169	241	1544	1099	--
X =	1563.43	1456.00	1259.69	647.60	1462.00	1384.89	266.48	1497.70		
S =	189.87	209.6	169.70	179.69	467.72	293.85	82.46	155.29		
CV% =	12.14	14.39	13.47	27.75	31.00	21.21	30.95	10.37		
DMS.05 =	316.56	349.46	183.09	300.00	779.83	489.93	137.55	258.91		

Table 142. VICAR (black-seeded) 1983B. Summary of the average yields in kg/ha, standard deviations, coefficients of variation, D.M.S. at the .05 level and percentage yield over local checks.

Identification	Gatemala Jutiapa	Honduras San.Fco.del Valle	Nicaragua Carazo	X	% Over local checks
ICTA L 81-64	2570	1537	1750	1952	31
ICA PIJAO	2598	1247	1882	1909	28
COMP. 1	2210	1276	2182	1889	26
ICTA TAMAZULAPA	2664	1314	1668	1882	26
ICTA QUETZAL	2488	1141	1978	1869	21
ICTA L 81-26	2516	1308	1779	1868	18
PORRILLO SINTETICO	2231	1347	1983	1854	24
XAN 112	2345	1159	1987	1830	13
BRUNCA	2486	1380	1552	1806	21
NEGRO HUASTECO 81	2104	1052	2170	1775	19
TURRIALBA 1	2508	1236	1566	1770	18
CENTA TAZUMAL	1900	1175	2212	1729	16
XAN 87	2328	978	1747	1684	13
TALAMANCA	2154	897	1725	1592	6
ICTA JUTIAPAN	1790	1187	1547	1508	-
LOCAL CHECK	2043	1015	1423	1494	-
X	2309	1203	1816		
S	308	244	232.6		
CV%	13.3	20.3	12.8		
DMS .05	178.0	407.2	404.3		

Table 143. VICAR (black-seeded) 1984A. Summary of average yields in kg/ha. Standard deviation, coefficient of variation, D.M.S. and percentage yield over local controls.

Identification	Guatemala Jutiapa	Guatemala Cuyuta	El Salvador Ahuachapan	Honduras Zamorano	X	% Over local checks
ICTA L 883-2-M	2093	998	1097	1688	1469	41
ICTA 81-31	2648	977	871	1273	1442	39
XAN 87	1851	1172	932	1698	1413	36
TALAMANCA	2451	863	918	1390	1406	35
ICTA 81-64	2060	1052	1007	1404	1381	33
ICTA TAMAZULAPA	2208	1056	1006	1184	1364	31
ICTA QUETZAL	2098	935	1079	1186	1325	27
BAT 450	1863	1057	1014	1313	1312	26
XAN 93	1767	1049	912	1448	1294	24
XAN 112	2679	642	1038	788	1287	24
NEGRO HUASTECO	2197	833	953	1028	1253	20
BRUNCA	2066	592	984	1256	1225	18
BAT 1636	1798	892	790	1353	1208	16
PORRILLO SINTETICO	2207	476	749	972	1151	11
TURRIALBA 1	1854	521	812	1150	1084	4
LOCAL CHECK	1964	637	846	713	1040	--
X	2113	860	951	1240		
S	487.9	267.2	116.6	407.6		
CV%	23.0	31.0	12.27	32.8		
DMS .05	459.4	154.3	67.35	235.3		

Table 144. Average yields of beans in kg/ha at 14% moisture content in on-farm varietal trials in relay with maize on five locations in the agrarian reform area of the Pacific coast in Guatemala, with CITA 84B.

Treatment	Identification	Average yields of 3 replications/Treatment						
		Rosario	Calderin	Montañita	Caballo Blanco	Santa Fe	X	% over control
9	ICTA 81-53	1355	1820	1710	1202	1124	1442	89
15	BAT 450	1416	1796	1565	1175	1165	1423	87
3	ICTA Quetzal	1274	1517	1388	1278	1309	1353	77
12	ICTA 883-2-M	1121	1614	1719	1108	1047	1322	73
6	ICTA 81-64	975	1606	1286	1093	974	1187	56
8	ICTA 81-31	759	1681	1291	1070	924	1145	50
5	Brunca	1243	1645	1221	889	533	1106	45
14	ICTA 81-4	895	1493	1224	911	877	1080	42
2	ICTA Tamazulapa	1089	1308	998	918	1069	1076	41
1	Negro Huasteco	1089	1390	1034	855	852	1044	37
10	XAN 93	955	1256	987	952	1062	1043	37
4	Talamanca	996	1343	924	909	929	1020	34
13	BAT 1636	813	1368	1061	1031	773	1009	32
16	Turrialba 1	705	1176	923	1028	905	947	24
11	Porrillo Sintético (Control)	529	880	972	663	770	763	-
7	XAN 112	313	658	372	482	428	450	-41
	X	971	1409	1167	973	921	1088	

Combined analysis DMS = 166.759
C.V. = 26.54

Table 145. Average yields in kg/ha of an on-farm varietal trial conducted in six locations in the Dominican Republic in 1983/84.

Identification	Average yield in kg/ha at 15% moisture content: San Cristobal Loc. 1	San Cristobal Loc. 2	Quirigua	Sn. Juan de la M. Loc. 1	Sn. Juan de la M. Loc. 2	MOCA	$\bar{x}$	% over control
DOR 214	2209	803	1230	981	2045	560	1305	104
BAT 1232	2283	751	1165	893	1887	701	1280	100
DOR 211	1671	780	1051	846	1763	621	1122	76
BAT 1412	2062	417	1007	803	1674	293	1043	63
BAT 1413	1874	373	1165	729	1519	545	1034	62
DOR 198	1610	480	990	844	1760	485	1028	61
JOSE BETA(control 1)	1884	260	881	745	1552	530	975	53
POMPADOUR(control 2)	1753	388	978	580	1209	497	900	41
BAT 1369	1476	432	873	742	1546	297	894	40
CONSTANZA (control)	1557	341	485	365	761	322	638	

Table 146. Summary of results from test plots in two locations in the Dominican Republic. Yields[a] expressed in kg/ha, 1983/84.

Identification	Location: Higuey	Location: MAO	$\bar{x}$	Percentage Yield over control
DOR 198	1831	1005	1418	25%
BAT 1412	1674	904	1289	14%
DOR 211	1250	1243	1246	10%
DOR 214	1164	1273	1218	7.6%
POMPADOUR	1464	800	1132	-
SR FR[b]	1582	1388	1485	40%
SR FA	1376	1208	1292	22%
SA FR	1553	863	1208	14%
SA FA (T.A.)	1398	723	1060	-

a Size of plots 400 m^2.

b SR = Chemical control of weeds
SA = Manual control of weeds
FR = Fertilization according to analysis
FA = Farmers´ fertilization regime

Table 147. Results of a demonstration plot in Constanza, the Dominican Republic, 1984.

Identification	kg/ha	% yield over control
BAT 1412	2.834	56%
DOR 198	2267	25%
PC 50	2442	35%
Pompadour (157)	1808	-

3. Brazil
Germplasm flow to Brazil

Specific advanced breeding lines and segregating populations of crosses made at CIAT are developed for Brazil. The objective in receiving the segregating populations is to increase breeding efficiency to obtain lines adapted to Brazilian conditions.

During 1984 the following nurseries arrived at CNPAF :

Web blight nursery 1983	100 entries
Anthracnose nursery	127 entries
Bacterial blight resistant sources	21 entries
Fusarium resistant sources	3 entries
Macrophomina resistant sources	3 entries

All materials entered the CAM through CENARGEN.

The segregating populations were not planted in CAM but were distributed to the corresponding scientists in charge of the testing. The segregating populations received during 1984 were:

Bacterial blight project	F-2 - 14 populations
	F-3 - 19 populations
BGMV project	F-2 - 9 populations
Angular leaf spot project	F-2 - 10 populations
	F-3 - 20 populations
Anthracnose project	F-2 - 16 populations
	F-3 - 34 populations
Empoasca project	F-3 - 10 populations
Drought tolerance project	F-2 - 3 populations
	F-3 - 8 populations
Low soil phosphorus project	F-2 - 14 populations
High yield potential project	F-2 - 99 populations
	F-3 - 24 populations

Joint breeding project. A letter of understanding to formulize and improve the existing collaboration between CNPAF and CIAT has been elaborated wherein the objective and modus operandi of the joint breeding project is described. The two institutions will meet at every crossing cycle to discuss and plan the upcoming crosses. The evaluations will be carried out in Brazil. CIAT will do back up work with the routine screening for most diseases. Advanced breeding lines of CNPAF may be sent to CIAT for the routine tests mentioned above.

Germplasm Evaluations in Brazil

CAM at IAPAR-IRATI/PR 1983. In September 1983, 4,058 lines were tested in IRATI/PR. All CIAT entries (873 advanced breeding lines) were included. CNPAF, IAPAR and CIAT scientists evaluated the nurseries in November 1983. The second evaluation was done only by CNPAF and IAPAR scientists. The results have been compiled and are available. Out of 873 CIAT advanced breeding lines tested, 274 entries ranked from resistant to intermediate to anthracnose under field conditions. From these 274, lines 180 were well-adapted and 120 lines met the Brazilian seed color requirements. These became the basic stock for the EPR 1985 - 1986.

CAM at IAPAR-IRATI/PR 1984. The web blight and the anthracnose resistant materials were evaluated at CAM in 1984. These materials, the segregating populations for disease projects, and CNPAF breeding lines, totaling 886 materials, were sent to IRATI/PR for anthracnose testing. The outstanding materials from CAM IRATI/PR will again be tested in VENDO NOVA/ES in 1985.

EPR (Ensaio Preliminar de Rendimento) of the NBERN (National Bean Evaluation and Recommendation Network).

EPR 1983 - 1984, results. The first cycle of the EPR 1983/84 was concluded. Out of 67 sets of experiments shipped, 27 data sets were reported. A great number of experiments were lost due to irregular rainfall. Losses due to disease or insect problems were not reported. The results are presented in Table 148 through 150 for cream-seeded, Table 151 to 153 for black-seeded and Table 154 for red-seeded lines. Without disease pressure, materials with highest yield potential will prevail and if the resistant lines are lower yielding they will be eliminated. This was the case with the black-seeded materials tested in southern Brazil. The 10 best varieties shown in Table 151 were those with resistance to anthracnose, whereas the 10 best varieties grown in the southeast of Brazil (such as in the State of Rio de Janeiro, Espiritu Santo and Minas Gerais) (Table 152) are not necessarily resistant to the disease (ICA Pijao, PV 99 N, PV 299 N).

Only a few red lines entered Brazil during 1984, but some lines outyielded the Carioca check (Table 154).

Most of the state institutional scientists selected 10 to 20 outstanding lines from the EPR for their state trials. The frequency of outstanding materials within the 20 best of the EPR is given in Table 155 for cream and black-seeded types, respectively.

EPR 1985 - 1986. The second series of EPR started its distribution in November 1984 for the wet season. The composition of the materials of this EPR is given in Table 156. All CIAT lines which entered the EPR have been tested for their P-efficiency, before EPR selection. Out of 126 materials tested, eight with a cream color, eight blacks and eight red-colored entries were classified as efficient in using of low soil phosphorus (Table 157).

Regional trials. Traditionally, the state institutions conduct trials only within the state's borders. However, during the two years of the EPR testing it was observed that there is a need to test the outstanding materials within a homogeneous agroclimatic region, beyond state borders. The first of such regional trials was started in the northeast of Brazil with participation of EPABA, EPEAL and Uepae ARACAJU. CNPAF will coordinate and provide the experimental materials in the same way as for the EPR. The trials will run for two years but the best materials from the first year will be immediately tested in farmers' fields. With this newly proposed system, new materials can be released within four years.

Released varieties during 1984. After three years of testing, the state institution of Bahia (EPABA) released one cream-seeded material, called EPABA 1 (EMP 86). About 50 tons of basic seed will be available for the release.

EMGOPA (Goias) released EMGOPA 201 = Ouro (A 295) and about 70 tons of basic seed is available.

PESAGRO of Rio de Janeiro released four new varieties. The fourth is the one that was released in Espiritu Santo, as Capixaba Precoce (BAT 3041). The other three varieties are: Xodo = Bat 58, Grande Rio = Bat 873, and Ipanema = Bat 904.

After releasing two black varieties two years ago) EPAMIG (Minas Gerais) released two cream-seeded varieties; Fortuna 1895 and Ricomig 1896 (BAT 160 and Bat 332, respectively).

All these released lines entered Brazil through the IBYAN for 1976 until 1981, except EMP 86 and A 295. These two came to Brazil through CENARGEN after visiting scientists finished their 6-8 months of training at CIAT.

Special Nurseries

Bean golden mosaic virus (BGMV). BGMV causes severe losses in the southern states of Brazil such as in Parana, the southern part of Minas Gerais, Sao Paulo and Mato Grosso do Sul. In the second semester (safrinha) when soya beans reach maturity the white flies migrate to the surrounding bean fields infecting the beans. When the infection is early, BGMV can destroy the crop.

A BGMV workshop was held between March 26 and April 3, 1984 with the participation of 14 scientists from several countries (Guatemala, Mexico, Brazil and Colombia). The objectives of the meeting were :

(1) To collect basic information on BGMV from several countries that have similar problems.
(2) To form a team consisting of several disciplines to develop viable strategies for BGMV resistance breeding.

The first part of the workshop was dedicated to visiting the nurseries prepared in IAPAR Londrina, EPAMIG Uberaba and CNPAF Rio Verde. In all three sites, 667 advanced breeding lines of the BFMV projects were planted.

The results of the meeting can be summarized as follows: to look for alternatives to breeding for the BGMV resistance, especially cultural practices; to do a survey of the host plants of virus; and to study the epidemiology of the white fly.

Bacterial blight nursery at PESAGRO in Campos / RJ. During the wet season planting about 25 advanced breeding lines resistant to bacterial blight were tested for their disease reaction and yield. Table 158 shows the 10 best lines of the nursery. The results suggest that lines with a reasonable level of resistance tend to yield low. XAN 87 and XAN 148 with good disease resistance yielded close to the susceptible checks, Rio Tibaji and Moruna.

Drought tolerant nurseries at IPA in Belem do Sao Francisco / PE. The northeast of Brazil is prone to drought during the growth period of beans. At IPA priority is placed on screening materials resistant to water stress. Two different experiments were conducted in 1982, one with water stress 30 days after germination and the other at flowering. The results shown in Table 159 and 160 suggest that stress at different growth stages gives different results.

Preliminary Yield Trials at EMPASC - Chapeco / SC, 1983/84. In 1982, EMPASC had received many materials from CIAT similar to those of the EPR. Therefore, EMPASC did not participate in the first series of EPR during 1983/84.

The black-seeded materials did not contain advanced breeding lines that significantly outperformed the local check, Rio Tibaji. On the other hand, the cream-seeded lines such as A 329, A 266, A 140 and A 176 yielded significantly higher than the check Carioca (Table 161).

Intercropping beans with maize conducted by EMCAPA in Venda Nova / ES. Twenty eight advanced breeding lines with growth habits IIB, IIIA and IIIB were intercropped with maize and in the following semester were relayed. The results of these nonreplicated trials is shown in Table 162. Some outstanding materials such as A 338, A 286, BAT 429 yielded well in intercropping as well as in the relay system.

Intercropping beans with sugarcane conducted by PESAGRO in Campos / RJ. Sugarcane is the main product of the northern part of the State Rio de Janeiro. For at least a 2-3 months period the space between the sugarcane rows is not properly used. PESAGRO conducted a series of experiments in a ratoon field. Table 163 shows the results of the experiments conducted in two locations. Lines such as ICTA Quetzal and PV 99 N gave an average yield above 400 kg/ha.

Table 148. The 10 best cream-seeded advanced breeding lines, their common checks and local checks tested in the EPR in north-East of Brazil (1983-1984).

EMEPA ALAGOINHA (PB)		UNIV.FED.DA BAHIA-CRUZ DAS ALMAS (BA)		EPABA/IPIRA (BA)		EPABA, IRAQUARA (BA)		EMCAPA, LINHARES (ES)	
Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha
				Advanced Breeding Lines					
1.A 352	1275	1.CARIOCA 80	1607	1.A 351	1600	1.A 359	805	1.A 322	2273
2.AROANA 80	955	2.A 301	1577	2.IPA CULT.9245	1500	2.A 282	659	2.BAT 731	2187
3.CENA 164	952	3.IPA CULT. 5400	1470	3.MUL.V.ROXA	1647	3.IPA CULT.6191	635	3.A 244	2125
4.A 281	933	4.A 281	1366	4.A 244	1450	4.A 286	627	4.A 294	2123
5.BAT 336	871	5.IPA-1	1341	5.A 281	1433	5.AROANA	601	5.A 359	1988
6.CARIOCA 80	862	6.A 357	1339	6.RICO PARDO 846	1417	6.A 351	583	6.A 364	1984
7.A 295	778	7.BAT 731	1307	7.EMP. 117	1417	7.A 338	559	7.CARIOCA 80	1976
8.A 247	768	8.A 249	1265	8.BAT 731	1367	8.MD 93	548	8.A 296	1908
9.IPA CULT.4211	762	9.MUL.VAR.ROXA	1208	9.IPA CULT.6191	1367	9.MD 71	545	9.A 295	1867
10.MD 71	752	10.BAT 332	1192	10.A 242	1350	10.A 160	537	10.A 358	1863
				Common Checks					
1.IPA 74-19	540	" "	1198	" "	1067	" "	645	" "	1278
2.CARIOCA	552	" "	369	" "	1233	" "	309	" "	1544
3.ROSINHA G2	738	" "	597	" "	467	" "	394	" "	1240
4.PARANA-1	347	" "	774	" "	917	" "	337	" "	1720
				Local Checks					
1.a	557	1.IPA 74-19	972	1.PITOCO	817	a	543	a	1198
2.a	675	2.IPA 74-19	856	2.RIN DO PORCO	1183	a	439	a	1538
3.a	490	3.IPA 74-19	888	3.SANTA ROSA	-	a	526	a	1537
4.a	365	4.IPA 74-19	1198	4.FAVINHA	1417	a	417	a	1642
MEAN (n°.)	544		876		1045		299		1481
L S D 5%	379		-		571		247		513
CV (%)	36,0		41,0		27,5		32,1		17,7

[a] Identification not reported

Table 149. The 10 best cream-seeded advanced breeding lines, their common checks and local checks tested in the EPR (10x10 lattice) in the central west region of Brazil (1983-1984).

EPAMIG - VICOSA (MG)		CNPAF - GOIANIA (GO)		CNPAF - GOIANIA (GO)		EMPAER - BODOQUEIMA (MT)		EMPAER - TERENOS (MT)	
Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha
				Advanced Breeding Lines					
1.IPA 1	2084	IPA CULT.1055	3693	IPA CULT. 1055	3433	JALO EEP 558	1450	A 212	1158
2.A 246	1944	IPA CULT. 5400	3423	IPA 1	3117	IPA CULT. 1044	1352	A 268	1046
3.A 377	1939	A 358	3364	A 294	2903	A 294	1272	A 248	1011
4.IPA CULT.6097	1929	EMP.89	3307	A 246	2867	A 294	1205	A 354	991
5.IPA CULT.1055	1918	A 282	3278	EMP117	2742	A 296	1192	IPA CULT. 1055	942
6.A 286	1884	BAT 731	3243	A 295	2725	VERMELHO	1164	IPA CULT. 6047	915
7.A 62	1876	A 286	3232	A 340	2697	BAT 332	1095	MD 71	901
8.A 358	1872	A 351	3198	IPA CULT.	2633	A 245	1083	A 73	899
9.A 288	1806	A 281	3182	BAT 160	2625	A 281	1060	BAT 731	846
10.EMP. 89	1803	CENA 164	3147	A 377	2608	A 358	1014	A 250	849
				Common Checks					
1.IPA 74-19	1479	" "	2602	" "	1625	" "	677	" "	812
2.CARIOCA	1216	" "	2558	" "	2637	" "	559	" "	814
3.ROSINHA G2	884	" "	2098	" "	1447	" "	232	" "	963
4.PARANA	1515	" "	2372	" "	1530	" "	434	" "	905
				Local Checks					
1. a	1126	LPM 10023	2240	LPM 10047	1317	CARIOCA	422	CARIOCA	809
2. a	1465	LPM 10045	1557	LPM 10027	1700	CARNAVAL	854	CARNAVAL	663
3. a	1126	LPM 10047	2227	LPM 10045	1617	ROSADO	207	ROSADO	901
4. a	1436	LPM 10027	1877	LPM 10025	1850	PARDINHO	396	PARDINHO	1033
MEAN (n°)	1375		2467		1997		669		643
L S D 5%	487		1336		882		297		243
CV (%)	18,1		27,6		22,6		22,6		23,3

[a] Identification not reported.

TABLE 150. The two best cream-seeded advanced breeding lines, their common checks and local checks tested in the EPR (10x10 lattice) in the south Brazil (1982-1984).

EUE MARINGA (PR)		UEPAE/DOURADOS (MS)	
Identification	Yield kg/ha	Identification	Yield kg/ha
	Advanced Breeding Lines		
1. MD 93	1044	IPA CULT. 1055	2583
2. IPA CULT. 1055	1013	A 268	2560
3. A 281	946	A 281	2487
4. IPA CULT. 6191	943	A 255	2447
5. A 244	918	IPA CULT. 7310	2447
6. A 282	849	IPA CULT. 1055	2413
7. A 250	834	BAT 332	2450
8. BAT 336	833	IPA 1	2377
9. A 354	823	MD 93	2300
10. IPA CULT. 6097	818	A 245	2293
	Common Checks		
1. a	447	a	1680
2. a	690	a	
3. a	368	a	1653
4. a	321	a	1693
	Local Checks		
1. RIO VERMELHO	112	CARIOCA	1813
2. CARIOCA	676	CARIOCA	2173
3. PAU DE FERRO	210	CARIOCA	2250
4. CNF 0061	92	CARIOCA	2130
MEAN (n°)	538		
L S D 5%	358		
CV (%)	33,6		

[a] Identification not reported

TABLE 151. The 10 best black-seeded advanced breeding lines, their common checks and local checks tested in EPR in the south Brazil (1983-1984).

Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha
		Advanced Breeding Lines			
1. BAT 1554	1733	VERMELHO	2073	BAT 1554	2083
2. BAT 429	1583	BAT 1470	1941	BAT 1470	1900
3. BAT 1647	1566	MD 64	1925	BAT 1647	1883
4. RAI 78	1500	BAT 1647	1872	BAT 451	1817
5. RAI 79	1416	BAT 67	1850	A 226	1817
6. EMP 60	1400	ICA PIJAO	1821	CORNELL 49242	1800
7. BAT 67	1400	CNF 0121	1816	PV 99N	1800
8. RAI 77	1350	A 222	1820	CNF 0145	1783
9. PARANA-1	1283	BAT 451	1095	A 227	1767
10. BAT 431	1267	CORNELL 49242	1682	EEP 710/75	1750
		Common Checks			
1. RIO TIBAGI	567		1302		1267
2. CARIOCA	733		1326		1450
3. ROSINHA G2	617		877		1117
4. RICO PARDO 896	617		1234		2050
		local Checks			
1. UNKNOWN	900	" "	1116	" "	1417
2. "	817	" "	1695	" "	1667
3. "	783	" "	1152	" "	1530
4. "	700	" "	1494	" "	1483
MEAN (n°)	912		1341		1475
L S D 5%	494		564		374
CV (%)	27.6		21.6		13.0

Table 152. The 10 best black seeded advanced breeding lines, their common checks and local checks tested in the EPR in southeast Brazil (1983-1984).

EPAMIG - VICOSA (MG)		EMCAPA, CONC.DE CASTELLO (ES)		PESAGRO, CAMPOS (RJ)		PESAGRO, CAMPOS (RJ)	
Identification	yield	Identification	yield kg/ha	Identification	yield kg/ha	Identification	yield kg/ha
		Advanced Breeding Lines					
1. BAT 549	2309	VERMELHO	2067	BAT 1647	1095	BAT 429	1541
2. CNF 0158	2135	EMP 60	1883	PV 299N	995	BLACK TUR.SOUP	1482
3. BAT 431	2122	A 227	1883	CNF-0141	930	CNF 0115	1440
4. PV 99N	2027	ICA PIJAO	1850	CNF-0115	925	VERMELHO	1427
5. BAT 148	1905	BAT 451	1835	ICTAQUETZAL	900	CNF 0121	1416
6. BAT 1191	1835	CNF 0122	1808	A 202	900	EF 33	1401
7. EMP 84	1823	EMP 84	1800	MD 64	841	BAT 1060	1373
8. MD 64	1755	RICO 23	1732	CNF-0122	833	BAT 148	1365
9. RAI 78	1692	PU 94N	1716	CNF-0144	808	RAI 79	1355
10. RIO TIBAGI	1678	A 236	1708	CNF-0145	800	RAI 78	1344
		Common Checks					
1. RIO TIBAGI	1678	" "	1367	" "	532	" "	1218
2. CARIOCA	1397	" "	1267	" "	755	" "	1340
3. ROSINHA G2	847	" "	950	" "	375	" "	1355
4. RICO PARDO 896	1460	" "	1700	" "	180	" "	1471
		Local Checks					
1. a	1387	CARIXABA PREC.	1665	BAT 58	1088	MORUNA	1013
2. a	1400	PITOCO	1409	57051	825	BAT 58	1224
3. a	1174	IGUACU	1758	MORUNA	793	BAT 304	1396
4. a	1198	RIO TIBAGI	1741	C 3689 PN2, 1	797	51051	955
MEAN (n°)	1443		1424		535		1131
L S D 5%	587		422		381		506
CV (%)	20.8		14.8		35.8		22.8

TABLE 153. The 10 best black-seeded advanced-breeding lines, their common checks and local checks tested in EPR in the central Western part of Brazil (1983 - 1984).

CNPAF - GOIANIA (GO)		EMGOPA - ANAPOLIS (GO)	
Identification	Yield kg/ha	Identification	Yield kg/ha
ADVANCED BREEDING LINES			
1. BAT 1647	2914	RAI 72	3105
2. BAT 431	2894	PN 99N	2735
3. BAT 427	2725	EEP 527/75	2567
4. ICTAQUETZAL	2722	BAT 429	2402
5. PV 99N	2694	RAI 71	2233
6. EMP 84	2541	RAI 70	2192
7. BAT 1191	2378	BAT 1060	2162
8. CNF-0178	2371	ICTAQUETZAL	2142
9. CNF-0173	2368	BAT 67	2137
10. RICO 23	2339	A 210	2105
COMMON CHECKS			
1. RIO TIBAGI	1665	" "	2062
2. CARIOCA	1763	" "	1912
3. ROSINHA G2	1012	" "	140
4. RICO PARDO 896	2147	" "	1885
LOCAL CHECKS			
1. LPM 00628	1844	CENA 164	1913
2. LPM 00264	1972	ICA COL 10103	1332
3. LPM 00159	2305	A 295	2065
4. LPM 00565	2026	AY50	1777
MEAN (n°)	1784		1759
L S D 5%	743		543
CV (%)	21,3		15,7

Table 154. The 10 best red-seeded advanced-breeding lines, their common checks and local checks tested in EPR in the center West of Brazil (1983-1984).

CNPAF - GOIANIA (GO)		EMGOPA - ANAPOLIS (GO)		EMGOPA - ANAPOLIS (GO)	
Identification	Yield kg/ha	Identification	Yield kg/ha	Identification	Yield kg/ha
		ADVANCED BREEDING LINES			
1. BAT 1458	2817	LPM 30068	2077	LPM 30068	1613
2. XAN 37	2533	LPM 10092	2055	LPM 10033	1612
3. XAN 57	2483	BAT 1550	1943	BAT 1512	1503
4. LPM 10092	2333	LPM 10089	1763	LPM 10100	1490
5. BAT 614	2283	LPM 10348	1725	ROXAO RG	1477
6. LPM 10033	2183	BAT 1458	1710	LPM 10103	1447
7. LPM 30068	2158	LPM 10034	1655	BAT 363	1435
8. BAT 1510	1908	CNF 0168	1583	A 482	1403
9. BAT 258	1883	BAT 363	1578	CNF 0168	1395
10. LPM 30013	1883	BAT 614	1550	LPM 10069	1298
		COMMON CHECKS			
1. IPA 74-19	1317	" "	1280		1542
2. CARIOCA	1960	" "	1555	" "	1212
3. ROSINHA G2	900	" "	740	" "	715
4. RICO PARDO 896	2667	" "	1407	" "	1348
		LOCAL CHECKS			
1. CNF-0105	992	EMGOPA 201	1347	EMGOPA 201	993
2. CNF-0009	1228	CNF-0013	885	AX 50	1087
3. CNF-0051	1233	CARIOCA	1013	IPA-1	1443
4. CNF-0013	808	PARANA 1	1038	PARANA-1	1328
MEAN (n°)	1515		1270		550
L S D 5%	727		511		505
CV (%)	24.5		20.5		22.9

Table 155. Frequency of advanced breeding lines found within the best entries of the EPR 1983-1984.

Frequency				
9x	8x	7x	6x	5x
Cream-seeded (15 expts)				
A 281		A 294	A 295	A 338
A 286			A 282	A 247
IPA 1			A 245	A 255
IPA cult. 1055			BAT 332	A 351
			BAT 731	EMP 117
			IPAcult 6097	MD 71
			IPAcult 6191	MD 93
Black-seeded (9 expts).				
EMP 84		BAT 431		MD 64
		BAT 67		BAT 1647

Table 156. The origin of materials in the 84-86 EPR.

Institution	Black	Cream	Red	Total
1. CNPAF	35	19	27	81
2. IPA	1	25	-	26
3. ESAL	-	7	2	9
4. VICOSA	4	-	-	4
5. CENA	-	1	-	1
6. UNIV. WISCONSIN	5	-	-	5
7. CIAT	27	38	11	76
Total tested lines	72	90	40	202
Common checks	5	6	5	16
Local checks	4	4	4	12
TOTAL	81	100	49	230

Table 157. Average yield of outstanding lines under P stress and non-stress conditions in CNPAF - Goiania.

Identification		Yield kg/ha		
		Without stress	P-Stress	Response
Cream Seeded	1. A 275	2893	1523	11,4
	2. 82 PVBZ 1771	2946	1414	12,8
	3. 82 PVMX 1637	2128	1376	6,3
	4. 82 PVBZ 1758	2217	1325	5,9
	5. 82 PVBZ 1785	2593	1300	10,8
	6. 82 PVBZ 1901	2698	1245	11,7
	7. 82 PVBZ 1743	1803	1145	5,5
	8. 82 PVMX 1638	2148	1141	8,4
Checks	CARIOCA	2433	1387	8,7
	CARIOCA 80	2571	1106	12,2
	MEAN (n = 40)	2146	918	10,0
Black Seeded	1. NAG 24	3155	1506	13,7
	2. DOR 218	2450	1358	10,1
	3. 82 B VAN 38	2599	1317	10,7
	4. NG 52	1882	1280	5,0
	5. BAT 1060	2141	1266	7,19
	6. NAG 37	2346	1266	9,0
	7. A 230	2687	1251	12,0
	8. NAG 24	2510	1222	10,7
Checks	RIO TIBAGI	3069	1141	13,8
	PRETO 132	2517	1274	10,4
	MEAN (n = 43)	2466	1149	11,4
Red Seeded	1. 82 PVBZ 1736	2551	1334	10,1
	2. 82 B VAR. 112	2341	1137	10,1
	3. 82 B VAR. 178	2387	1077	10,9
	4. 82 B VAR. 179	2828	1028	15,0
	5. RAO 23	2425	982	12,0
	6. RAO 26	2349	919	11,9
	7. 82 PVBZ 1838	2229	904	11,8
	8. 82 PVBZ 1839	2061	880	9,8
Checks	BAT 41	2313	1022	10,8
	CNF 10	1841	691	9,6
	MEAN (n = 43)	1959	787	9,8

Table 158. The 10 best lines in terms of disease severity and yield performance from bacterial blight nursery conducted by PESAGRO Campos, RJ 1984.

Identification	Disease[a] score	Yield (kg/ha)
1. XAN 40	2,0	663
2. XAN 41	2,1	500
3. XAN 113	2,2	561
4. XAN 87	2,6	822
5. XAN 148	2,7	835
6. XAN 115	3,2	400
7. Porrillo	3,3	975
8. BAT 116	3,3	376
9. XAN 93	3,3	644
10. BAT 1647	3,5	802
CHECKS		
Moruno	4,2	969
BAT 58	4,2	505
RIO TIBAGI	4,2	844
CAPIXABA PRECOCE	4,3	804
PV 99N	4,3	909
Mean (n = 25)	3,6	696
L S D 5%	0,99	504
CV (%)	9	19

[a] 1 = resistant; 5 = susceptible

Table 159. Outstanding lines of 50 entries in the drought tolerance nurseries tested under non-stress and water stress at 30 days after germination, conducted by IPA - Belem Sao Francisco 1982.

	Yield kg/ha		
Identification	Non-stress	Water stress at 30 days after germination	Average yield
1. BAT 85	2910	2312	2611
2. BAT 18	2475	2190	2332
3. BAT 518	2525	2175	2350
4. BAT 128	2507	2118	2212
5. IPA L 5155	2262	2110	2186
6. IPA L 9214	2537	2022	2280
7. EMP 17	2422	1975	2198
8. G 5694	2122	1972	2047
9. BAT 247	2207	1960	2084
CHECKS			
1. IPA 5	2190	1962	2076
2. IPA 74-19	1775	2032	1904
3. IPA 1			
Mean (n = 50)	2200	1813	2006
Yield range	2910-1914	2312-1612	-

Table 160. Outstanding lines of 50 entries in the drought tolerance nurseries tested under nonstress and water stress at flowering time conducted by IPA - Belem Sao Francisco 1982.

	Yield kg/ha		
Identification	Nonstress	Water stress at flowering	Average yield
1. BAT 148	2288	642	1465
2. BAT 117	3035	595	1815
3. BAT 128	2307	514	1410
4. IPA L 9111	2090	502	1296
5. IPA L 4066	2572	488	1530
6. BAT 18	2476	488	1481
7. IPA L 9150	1875	484	1179
8. IPA L 1055	2422	479	1450
9. IPA L 7012	2382	462	1422
10. IPA L 9103	2535	461	1498
CHECKS			
IPA 5	2190	508	1347
IPA 74-19	1775	311	1043
IPA 1	2280	262	1271
Mean (n = 50)	2200	334	-
Yield range	1403-3035	110-642	-

Table 161. Preliminary yield trials conducted by EMPASC - Chapeco/SC. 1983/84.

Identification	Yield kg/ha
Black-seeded	
BAT 1647	2261
EMPASC 201	2249
EMP 60	2036
EMP 84	2086
BAT 1060	2081
BAT 108	2022
BAT 1432	2012
Mean (n=19)	1950
Checks	
Rio Tibagi	2104
Turrialba 4	1948
Cream-seeded	
A 329	2811
A 266	2335
A 140	2238
A 176	2225
A 59	2158
A 73	1917
A 338	1912
A 163	1860
EMP 86	1801
Mean (n = 14)	1959
Check	
Carioca	1843

Table 162. Outstanding lines intercropped and in relay with maize conducted in by EMGAPA in Venda Nova, Espiritu Santo 1983/84.

Intercropped			Relay		
Identification	Yield kg/ha bean	Maize	Identification	Yield kg/ha Bean	Maize
1. A 338[a]	475	3860	A 294	1345	5090
2. A 286	460	4325	A 382	1320	4825
3. A 210	420	4280	BAT 1432	1305	4650
4. SPj 3	410	2720	A 277	1160	5285
5. A 266	400	3320	BAT 429	1108	4150
6. SPj 6	400	2525	A 286	1085	4325
7. BAT 429	385	4150	A 338	1080	3860
8. EMP 84	385	3970	A 372	1070	-
9. PRETO 20-34	375	2625	CNF 0119	1070	4700
10. VENEZUELA 35085	370	2400	EMP 84	1055	3970
Checks					
CAPIXABA PRECOCE	490	4700	" "	1320	4700
VITORIA	300	5610	" "	935	5610
RICO PARDO 896	440	4375		1085	4375

[a] Underlined materials were good in both cropping systems.

Table 163. Beans intercropped with ratoon sugarcane in two locations at PESAGRO-Campos/RJ, 1983.

Identification	Location and yield kg/ha		Average yield
	TAI	Colegio Agricola	
PV 99N	505	400	452
Icta Quetzal	543	356	450
MD 64	440	415	427
Moruna	420	380	400
Rio Tibagi	158	320	239
BAT 906	356	317	336
Porrillo Sintetico	332	325	328
BAT 58	375	250	312
51051	296	310	303
BAT 873	273	318	295
Costa Rica	303	240	271
EMP 84	258	283	270
RAI 78	235	300	267
DOR 62	348	180	246
BAT 304	313	215	246
Colombia PN2-1	298	225	261
Jamapa	242	270	256
M 69/60	245	265	255
Average	330	298	314
L S D 5%	199	189	
CV (%)	22	25	

4. Peru

The CIAT regional project to promote agricultural research and extension of beans in Peru has been functioning for 18 months. Project activities continued to support the development of regional grain legume programs in 16 CIPA centers (Centros de Investigacion y Promocion Agropecuaria) of a total of 18 with which the Instituto Nacional de Investigacion y Promocion Agropecuaria (INIPA) works in Peru.

This past year a special effort has been made to organize work groups of researchers and extensionists in each CIPA to annually plan and review each of the projects oriented toward the solution of a specific problem. It was also possible to better define the production problems which confront the three principal agroecological regions of Peru-the coast, the sierra, and the jungle.

On the coast the factors which most affect bean production are: root rots, water stress, the bean common mosaic virus (BCMV), rust, the leaf miner and nematodes. In the sierra region, the factors which are particularly incident on production are those critical diseases known as Ascochyta leaf spot, anthracnose, and halo blight. In the jungle (the humid tropics) the most problematic disease is web blight, together with the problem of aluminum toxicity in the soils.

The establishment of these priorities has not only affected the intensity the bean crosses in Peru and in CIAT but also the study of segregating populations which in the mid-term will make possible the development of more productive and efficient varieties than the local cultivars.

The evaluation of advanced bean populations has produced highly promising lines in diverse regions of Peru, and basic seed is being multiplied of these future new varieties.

I. General Activities

A. Internal Reviews for the evaluation and planning of research-extension projects

According to the program laid out in 1983, 28 workshops were organized and carried out with the participation of 15 INIPA research centers. For the first time, the researchers and extensionists of each food legume program at the national level, analyzed and discussed together their working activities. Furthermore, the results of these discussions and the future plans were recorded in a document.

B. Organization and coordination of the "III Annual Meeting of the INIPA National Food Legume Program in Peru"

This meeting was held from October 1-3 last year with the participation of scientists from the 16 CIPA's. Here, the principal results and advances of 1983-84 were analyzed with respect to beans and six other food legume species.

Principal research results and progress in Peru

A. The coast of Peru

With reference to the identification of better sources of resistance to diseases, five lines were identified and are shown in Table 164. These lines were resistant to BCMV and rust, and were well adapted in the Chincha valley.

Additionally, some lines with improved tolerance to the leaf miner, *Liriomyza huidrobensis*, were observed in a study carried out in the central coast of Peru (Table 165).

Table 164. Bean lines with improved adaptation and resistence to BCMV and rust at the Chincha Experimental Station, 1983-84.

Lines	Growth habit	Grain color
BAT 1728-5-2-CM (10-A)M	1A	Cream
CC6002-14-3-CM(8-A)-4-1-2-CM-CM(20-A)	1A	Yellow
CC6002-50-3-2-M-M-IM-CM(10-C)	1A	Bayo
CC7332-4-2-1-2-CM(10-C)	2B	Yellow
FB 8789-CM(10-C)-18-CM(10-A)-M	1A	Bayo
Canario Divex 8130 (susceptible check)	1A	Yellow

Table 165. Bean lines with improved tolerance to the leaf miner, *Liriomyza huidrobensis* at the "La Molina" Experimental Station, 1983-84.

Lines	Grain color	Adult insects (%)	Foliar area damaged (%)
POP FB04298-101-1-1-3-2-CM(5-A)F8	White	10	5.0
XAN 127	Bayo	20	6.0
BAT 1372	Bayo	15	7.5
MICH 212	White	20	7.5
A-335	Brown	20	7.5
Canario Divex 8130	Yellow	45	30.0

A new research area was initiated in two semi-desert areas of the coast (in the departments of Lambayeque and Ica) on adaptation to drought. Out of the 75 lines studied at the Chincha Experimental Station during the winter planting in April, the most efficient lines were BAT 125, A 54, BAT 798 and V-8025.

The recent selection of many of these outstanding genotypes for their characteristics of resistance to diseases, insects and other adverse environmental factors at the Chincha Experimental Station, has resulted in several crosses for the improved lines and genetic populations. Here, 365 crosses were made principally to improve the following bean types: yellow Canario, blanco local, common Bayo, and Blanco Caballero. Other crosses were made at CIAT with these same types, in addition to the segregating populations which were organized to improve "summer beans" with tolerance to high temperatures and "Huascaporoto beans" from the humid tropics of Peru.

A special group of genotypes used in the crosses is the yellow Canario, medium-sized bean types with resistance to BCMV produced by CIAT and which are shown in Table 166 Experiments are currently being carried out to determine if any of these lines are as productive as the local variety, Canario Divex 8120.

Table 166. Yellow Canario bean lines with resistance. to BCMV.

Line	Growth Habit
CC07332-4-2-1-3-CM(10-C)-M	2
CR8811-CM(24)-4-2C-3A-M	3
CR8812-CM(24)-M-13 B-M-(10-A)-M	1
CR8812-CM(20)-M-M-M-6B-M(12-A)	1
CR8811-CM(24)-M-11C	3
CR8811-CM(24)-M-12C	3
CR8811-CM(24)-M-13C	3
CR8812-CM(20)-M-19A	1
CR8812-CM(20)-M-20B	1

Canario Corriente, Canario Divex and other big-seeded lines (45-55 grams) are being used directly in crosses to increase the seed size of these resistant lines having the yellow Canario grain type.

Of the new experimental varieties on the coast of Peru, the most promising are shown in Table 167. Of these experimental varieties, EMP 86 and BAT 1061 with resistance to BCMV are being evaluated at the commercial level and basic seed is being increased to select one of them for release as a new variety in the region in 1985. Similarly, the experimental variety VF-8 which is also resistant to BCMV has been outstanding not only in the Chincha valley (Ica) but also in the Paijan valley (Trujillo). Basic seed from this variety is being increased on eight hectares for release as a new commercial variety too.

B. <u>The Sierra of Peru</u>

To provide a more rapid solution to the principal problem affecting bean production in this region (fungal diseases) new genotypes were selected with resistance to Ascochyta leaf spot, Table 168. Those genotypes with improved characteristics of adaptation will be included in crosses which are being carried out at CIAT, principally to improve the local variety Blanco Caballero (which has the highest demand in the region) as well as the local variety Amarillo Gigante and other Red Kidney type beans in the Cuzco area. (The headquarters for the genetic improvement of beans through the Sierra region will be located at the Cajabamba Experimental Station.)

The experimental varieties which are more productive, resistant and are, the most promising for the Cajabamba area are G 2829, Puebla 444 and Cajamarca 64-1. These bean varieties are being analyzed in commercial fields to decide which one should be released as a new variety in 1985.

The most outstanding experimental varieties among the small white and big red grain types for the zones of Chumbibamba, Yanatile and Mollepata in the department of Cuzco are shown in Table 169. From these promising beans, new varieties will be released in 1985. At present, 2.5 tons of basic seed have been produced for each of the best varieties.

C. The tropical rain forest of Peru

The humid tropics of Peru known as the jungle region is the most extensive of the agroclimatic zones covering 61% of the national territory with 785,000 km^2. Research support in beans was initiated for five CIPA´s located in the region.

- After having identified web blight as a critical disease in the region and one of the principal limiting production factors, three nurseries were established in August 1984 in the zones of Requena (Iquitos), Tarapoto and Pucallpa to identify tolerant lines to this disease with acceptable production levels.

- In a joint effort with the national program, crosses were initiated at CIAT with Huascaporoto beans form Iquitos to incorporate resistance to web blight.

- In the 1984 annual review of the National Program of Food Legumes, the El Porvenir Experimental Station at Tarapoto in the department of San Martin was designated as the hybridization headquarters for the jungle region.

- A regional trial was established with 78 lines of the Huascaporoto type from the CIAT Germplasm Bank in six jungle zones of Peru.

Table 167. Productivity (t/ha) of the white small-seeded experimental varieties which are most promising for the Peruvian coast.

Experimental Variety	Departments	
	Lambayeque	ICA
A - 96[a]	1.5	
EMP-86[a]	1.4	
BAT 1061	1.0	
VF-8		1.8
W-126		1.3
VF-4a		1.3
Sanilac (control)		0.6
Panamito mejorado (control)		0.5

[a] Bayo small-grained

Table 168. Bean lines resistant to Ascochyta leaf spot or anthracnosis in the experimental fields of Ccaytupampa and Mollepata in the department of Cuzco, 1983-84.

Lines resistant to Aschochyta		Lines resistant to Anthracnosis
G 35182	BAT 1569	V-8043
G 6040	A 182	V-7920
C-5969	A 117	A 411
BAT 1486	A 116	A 252
BAT 1251	EMP 81	A 262
BAT 1232	UNA-81006	
BAT 1222	G 10889[a]	

[a] Selected at the Cajabamba Experimental Station in Cajamarca.

Table 169. Productivity in t/ha of the most promising experimental bean lines in the bean production zones of Cuzco, 1983-84.

Experimental varieties	Chumbibamba zone	Yanatile and Mollepata zones
Linea 24	3.0	--
Linea 23	2.9	--
Linea 22	2.6	--
Red Kloud	1.4	--
Red Kidney (control)	0.9	--
W-126		2.1
ICA-Bunsi		1.6
Panamito comun (control)		1.2

In a yield trial carried out in the zone of Tarapoto during the production cycle of 1983-84, CIAT line 1029 was very promising (Table 170). This is a bush bean line with a golden yellow grain which is highly accepted in the zone. It produced 0.9 t/ha which was highly superior to the yield of the native variety. This experimental line is being multipled for more extensive evaluations on farmers' fields and to determine in the near future if this line should be released as a commercial variety for the zone.

Table 170. Outstanding lines from yield trials of bush beans in Tarapoto, San Martin, 1983-84.

Lines	Grain color	Days to harvest	Yield (t/ha)
CIAT 859	Cream	68	0.96
CIAT 1026	Cream	70	0.93
CIAT 1029	Yellow-gold	69	0.90
Allpa Poroto (control)	Purple	80	0.13

Training

The second intensive postgraduate research course on bean production in Peru was carried out with the participation of 26 scientists of which 16 were researchers and 10 were extensionists. Seven participants came from the coast of Peru, 11 from the sierra and eight from the humid tropics.

Nine peruvian scientists were trained at CIAT of which three worked in seed technology, three in on-farm research, one in water management and adaptation to drought, one in agronomy and another in phytopathology.

Work Diagnosis

- Disciplinary working groups in 16 CIPA´s were structured and organized and training of scientific personnel was highly promoted.

- Production of basic seed was enhanced, nevertheless, a mechanism must be established for the production of registered and certified seed with the interaction of cooperatives or private producers.

- A well established network of regional trials can now be organized and for the coast, the sierra and the humid tropics; the release of more productive varieties should be accelerated as well as the efficient development of hybridization centers which will support 'the generation and distribution of new genotypes through the three agroclimatic regions.

- The central germplasm bank of the national food legume program which was installed at the La Molina Experimental Station of INIPA, will be organized to preserve germplasm collections as well as valuable introductions.

5. Eastern Africa

Project objectives

The ultimate goal of the regional program on beans in Eastern Africa (Kenya, Uganda, Ethiopia, Somalia) is to improve the nutritional status and income of the poor, giving emphasis to small holder production. This may be achieved in part by increasing the productivity, production and consumption of beans by developing improved cultivars and more productive systems of their cultivation. Each relies substantially on strengthening national agricultural research capacity, and developing effective collaboration thereafter.

Strategies and emphases

CIAT's strategy in Eastern Africa has three fundamental components:

(1) the local evaluation of a greatly increased diversity of *Phaseolus* germplasm, placing emphasis on genotypes possessing potentially appropriate characters in work in Latin America where the species is native;

(2) the conduct of agronomic on-farm trials , using promising cultivars as the pivot of more productive husbandry, which must not rely substantially on added input nor disrupt farmers' traditional practices and preferences;

(3) the selective training of local scientists so as to build strong national programs dedicated to the improvement of beans, emphasizing both academic training overseas and technical training within the region. Efforts will be given to developing an effective communication network among bean scientists in Africa.

While recognizing the uniqueness of continental Africa, CIAT also recognizes the opportunities afforded by the judicious horizontal transfer of cultivars and of technology already available within Latin America. Careful analysis of the physical, biotic and socio-economic environments, leading to the definition of agroecological "microregions" in Africa, is likely to be a powerful tool in the effective local deployment of improved cultivars and their cultural practices.

Progress and problems

CIAT placed its first scientist (a plant pathologist) on the Eastern Africa Project in September 1984. An operational base has now been established at Thika in Kenya, within the national Grain Legume Project. In the absence of a formal agreement between CIAT and the Government of Kenya, the establishment phase was made difficult, notably in the residence status of the staff member, the importation of project vehicles and personal effects, in the release of funds by the donors (USAID and CIDA), and the processing of introduced germplasm through quarantine. However, most of these early barriers to progress have now been circumvented, and the way seems set to fuller technical operation.

Contact has been established with a wide range of national and international scientific personnel within the region, and effective links have been established with the national programs, both within the ministries of agriculture and the universities of Kenya and Uganda. Links with Ethiopia and Somalia will be forged early in 1985. Preliminary information has been gathered on the farming systems of which beans are a part in Kenya, and priorities for joint research with the national team at Thika are being formulated. Field surveys of the bean-growing areas of Uganda, and further visits to the national team at Kawanda, are a high priority for 1985.

Whereas the latter depends on changes in security, the rate at which a full field program of trials can be established depends on the outcome of the current discussion over post-entry processing procedures of germplasm from CIAT. Furthermore, there is a need to establish a third-party quarantine service for seed bound for CIAT from Eastern Africa. It is anticipated that a plant breeder will soon be recruited to the project, to be based also at Thika.

6. Great Lakes Regional Bean Program

Introduction

This Swiss (SDC) financed regional bean project, which began in October 1983, is situated in the highlands of Central Africa. The project serves the great lakes region of Central Africa which includes Burundi, Rwanda and the Kivu region of Zaire, and closely collaborates with the national agricultural research institutes of these countries. The agricultural institutes of Burundi, Rwanda and Zaire are: Institut Scientifique et Agronomiques du Burundi (ISABU), Institut scientifique et Agronomique du Rwanda (ISAR), and Institut National des Etudes et Recherches Agricoles (INERA), respectively.

The objectives of the project are to strengthen the national research capacity and intraregional cooperation for the development of improved bean production technology for traditional and improved cropping systems, thereby leading to increased production of beans in the region. To achieve these objectives the primary strategies are; national scientist training, and cultivar and cultural methodology improvement. CIAT staff include a bean breeder, a pathologist, agricultural anthropologist and an associate nutritionist, while the agronomist position is still vacant.

Description of the Great Lakes Region

The Great Lakes Region is in the heart of the Central African highlands, on both sides of one branch of the Rift Valley system. Composed of high plateaus, volcanoes, and high mountain ridges on both sides of the rift, it ranges between 900 and 4,500 msl. Rainfall varies between less than 1000 mm in the East and along the Eastern edges of lakes Kivu and Tanganyka, to more than 1800 mm along both the Nile Zaire Crest and the mountain ridge in Kivu Zaire. The Central plateau region of Rwanda and Burundi receives between 1000 and 1400 mm of rain.

There are two major cropping and rainy seasons, from mid-September to early January and from late February to early June. The intensity and duration of the rainy seasons varies considerably from year to year. The dry seasons are longer and more pronounced in the East.

The region supports the highest population density in Africa, over 350 people per sq.km of agricultural land, with a projected density of over 500 by the end of the decade. Over 95% of the population is rural, with an average farm size of less than 1 hectare. In the most densely populated areas, such as the central plateau and the borders of Lake Kivu over 50% of the farms are smaller than 0.5 ha. The eastern part of the region is lower and hotter with more intense dry seasons and generally larger farms averaging about 3.5 ha. The central plateau is characterized by thousands of rolling to steep hills, separated by marshes which provide a dry season crop. It is extremely variable in soil composition and fertility. In terms of land area cultivated, bananas are the dominant crop, followed by beans, sweet potatoes, cassava and sorghum. The highlands of the Nile-Zaire Crest have soils with a high organic content, but are highly acidic and high in aluminium. Bananas and beans predominate in the more fertile valleys, cassava and sweet potatoes on the heavily eroded slopes, and maize, peas, beans, sorghum, wheat and potatoes on the higher fields.

Rainfall is more intense in the Zaire-Nile crest than in most other regions, with lodging and hail damage at times being serious problems. The western slopes down to lakes Kivu and Tanganyka have rainfall similar to the central plateau. The major crops are maize, climbing beans, bananas, cassava and sweet potatoes. The Eastern slopes on the Kivu Zaire side of the lakes (since it faces the prevailing winds.) receives considerably more rainfall, (About 1800 mm). The major crops are maize, beans, cassava and bananas.

In the region as a whole, beans are typically grown as varietal mixtures and intercropped with a wide range of other crops, especially bananas, maize, sweet potatoes, cassava, taro, and at higher altitudes, potatoes. Because of heavy population pressure, which has resulted in a scarcity of fertile land, fallow periods have declined and bean production has expanded into marginal land, causing average yields to drop from .9 t/ha to .7 t/ha, while total output has started to lag behind the population increase.

Large production increases through yield increases on currently cultivated land as well on more marginal land, will be required to support a population which is expanding at one of the fastest rates in Africa (3.5%). The primary yield-limiting factors are low soil fertilty, insects and diseases, yield potentials of local cultivars, considerable variation in the timing and amount of rainfall and a shortage of readily available staking materials for climbing beans.

Summary of project activities

After the arrival of the project bean breeder in October 1983, additional team members (the anthropologist, pathologist and nutritionist) joined the project in early 1984. In this initial year of the project, emphasis has been placed on the development of solid working relationships with the three national programs in the region each of which have active bean improvement programs. This was highlighted by the first contact and establishment of collaboration with INERA (Zaire) in March 1984. Collaboration with ISAR and ISABU was earlier established in 1982 and 1983, respectively. Frequent travel to INERA and the other national programs by both regional and other CIAT staff was critical to the establishment of a productive working exchange among national programs and CIAT.

Intra-regional cooperation also began this year with the establishment of a regional advanced varietal yield trial leading to the identification of new outstanding varieties for both Burundi and Rwanda. Concurrently, the three national programs of the region planted a large number of varietal selection trials. CIAT germplasm in these trials consisted of both breeding lines and segregating populations. Several promising breeding lines have been identified. Additionally, in disease nurseries, several well adapted sources of resistance to the region's major diseases have been identified. These have been used in crosses with local varieties in the development of new populations to be selected and evaluated by the region's national programs.

As production increases are ultimately linked to the cropping system and consumption patterns and preferences, emphasis has also been placed on acquiring bean production and consumption data. A nutritional quality laboratory has been established at ISAR, Rubona and the first data have now been analysed from a nutritional survey in northern Rwanda and cropping system surveys in the northern and central plateau regions of Rwanda. These surveys along with other less formal interviews have already supplied a wealth of critical information for the establishment of meaningful strategies toward the ultimate goal of bean production increases in the region.

Varietal Development. Though the first locally posted CIAT staff arrived in the region in 1983, CIAT has been cooperating with the region's national programs for more than two years, especially in the supply of germplasm in the form of international yield trials and nurseries of advanced breeding lines.

Local evaluation of CIAT germplasm has shown that many CIAT breeding lines are well adapted to the region's climate and soils. This germplasm offers to national programs both yield potential and resistance to local diseases. This year, (beginning with the October 1983 plantings) a large amount of CIAT germplasm was shipped to the region for evaluation in the various national program nurseries (Table 171) and included for the first time segregating generations of crosses between CIAT germplasm and local varieties.

The region's national programs have two or three primary stations for bean research (Table 172) and often plant test nurseries at other sites. These programs use similar varietal evaluation schemes, all under unprotected conditions that allow evaluation for resistance to diseases and insects in addition to yield evaluations.

Varietal evaluation begins with an introduction nursery that is typically not replicated. Materials in these nurseries may come from collections of local materials or introductions from other sources, especially CIAT.

Once the materials have passed this first level screening based on general adaptation (yield and disease resistance), they are passed on to secondary testing (essai triage). This stage is usually planted at several sites and is usually replicated at each location. The best varieties of each site are then passed on to replicated yield trials (essais préliminaires or comparatifs). Best varieties of these trials then go on to multilocation trials (essais définitifs, confirmatifs ou multilocaux) and often to on-farm evaluations before release to seed multiplication services or development projects for varietal distribution to farmers.

The number of CIAT breeding lines and accessions evaluated in the region has increased considerably over the last few years. This is illustrated by the number of advanced lines of CIAT origin that have recently been evaluated at ISAR. Where in 1982 there were only 67 lines tested which originated at CIAT, in the 1984 cropping season there were 1394 (Table 173). In addition, CIAT-originating lines are now found at all levels of varietal evaluation in the national bean programs. Out of the 40 best lines in the 1984 ISABU essai de triage, 24 accessions originated at CIAT. At ISAR, there are now more than 250 CIAT lines in all stages of varietal screening, including two, ICA PALMAR and V 79116, in on-farm trials (Table 174).

Since beans were introduced into the region several hundred years ago, bean varieties from all areas of Latin America have continued to be introduced as evidenced by the wide range of grain types and many similarities with those types from Latin American. Today, nearly all the typical Latin American grain types can be found in farmer's mixtures in the region. Given the acceptability of most grain types, nearly all grain type classes collected or developed at CIAT have possible applications in the region. While CIAT has introduced to the region varieties of all grain types, the program has concentrated especially on the Andean zone and Mexican highland grain types.

Of the Andean zone group (large red grain types), several new lines show promise such as PVAD 774, PVAD 1156 and PVAD 1407 that performed well in introduction nurseries at both INERA Mulungu and ISABU Mosso. These varieties, as most of those in the Andean zone, have acceptable grain types but like the group as a whole, do not show great promise in increasing bean production because of relatively limited yield potential.

Highland Mexican varieties on the other hand are highly promising as high-yielding varieties. Six highland IBYANS of Mexican grain type were planted in the region in the 1984 cropping season, and all gave encouraging results (Table 175). Several lines were outstanding such as A 344, BAT 1671, A 321, and Carioca. The grain type of these varieties is acceptable although seed size is somewhat smaller than the ideal. In addition, they tend to be slightly later than national program check varieties.

Other grain type classes that are acceptable in the region and tend to perform well are Brazilian grain types (Mulatinho, Carioca, and Roxo). Of 71 of these breeding lines introduced to ISABU, Mosso 1984B, 59% were advanced for further evaluations in the Mosso area. Red Central American varieties also tend to do well in certain areas of the region. Thirty-nine Central American varieties including Honduras 46, Rojo de Seda, RAB 182 and Desarrural were planted by ISABU on poor plateau soils in the frequently drought stricken Bugesera region in northern Burundi. All did well relative to the local mixture control and will be further tested in the 1985A season.

Intraregional cooperation among national bean research programs began this year with germplasm exchange in the form of a regional bush bean trial. For the first season in 1984B, the regional trial only included materials from ISABU and ISAR whereas recent plantings of the 1985A season also include materials from INERA. The objective of the regional trial is to compare the best of each national program's varieties at several sites throughout the region. Because the region is a relatively uniform highland area where the three countries share similar ecological zones, bean research in one country is often applicable to the others in the region. The regional trial and other intra-regional germplasm exchanges, therefore, offer advantages, in the form of research complementation and increases the number of varietal test sites available to each of the national programs. This is illustrated by this year's regional trial. The four best varieties from ISABU and ISAR were planted at three sites in both Burundi and Rwanda. The four replications at each site included a local farmer's mixture as the control and each treatment was bordered by the same local mixture for intergenotypic competition. Competitive ability is important for all varieties in the region as any variety released by the national programs will often be added to and grown in local mixtures.

Results of this trial are interesting in that a Rwandan variety, Ikinimba, was the highest yielding at each of the three Burundian locations. In addition, Dore de Kirundo, an ISABU selected variety, yielded highest overall in Rwanda. This same variety, a preferred grain type, performed so well in Rwanda that in the 1985A season it is now in several on-farm trials in addition to being multiplied for expected future needs.

It is also important to note that at some locations of the regional trial, especially Karama, the local farmer's mixture performed well relative to national program-selected pure line varieties.

While bush beans are extensively grown throughout the region, cultivation of climbing beans is more restricted. Though some fields of climbing beans are seen in most ecological zones in the region, extensive cultivation of climbing beans is limited to certain areas, being most highly concentrated on the western slopes of Nile-Zaire Crest. Climbing beans offer high yield potential with average yields often 1.5 to 2.0 times that of bush beans when grown under relatively fertile conditions. Results from the ISAR Rwerere 1984A "essai comparatif" illustrate the high yield potential of climbing beans in the region (Table 176) where lines such as G 858, ICA Viboral and regional varieties such as C8, Urunyumba 3, and Gisenyi 6 produced over 4 t/ha. Many of these same varieties such as G 2333 or other climbing bean lines such as V 79116 have also been excellent yielders at ISAR Rubona, a research station representative of the large and important bean production on the central plateau, of Rwanda.

Because of the availability of well-adapted local germplasm that has been identified by national programs, a major focus of the regional cultivar improvement program is the utilization of CIAT germplasm as donor parents of high yield potential and resistance to diseases and edaphic constraints in crosses with local varieties. Donor parents for these crosses are selected in the region's national program nurseries from materials sent from CIAT.

Those breeding lines that are identified as being high yielding and possessing resistance to one or more yield constraints are selected as parents. A large number of these crosses, often specifically requested by national programs, are now made each year at CIAT and are sent to the region as segregating generations.

In addition to the crosses made at CIAT, both ISABU and ISAR now have active crossing programs, making complementary crosses to those being made at CIAT and also emphasizing crosses among the best local varieties and selections. Selection among segregating materials in the region emphasizes such characters as resistance to BCMV, angular leaf spot and anthracnose, and yield under high and, increasingly, low fertility conditions. Selections must also have acceptable grain quality according to local criteria and be relatively early maturing to reduce risk in the event of an early end to the rainy season; drought tolerance is an important character for many areas in the region. Best selections from the crossing programs are passed on to the second level of varietal testing (les essais de triage).

ISABU first received segregating lines from CIAT during the second season this year. Forty-five F_4 bulk families from crosses made at CIAT were grown at ISABU, MOSSO and a total of 58 individual and five bulk selections were made from 22 of the crosses. These will be further evaluated in the 1985 seasons. During the dry season (1984C) a number of varieties, including Urubonobono, Doré de Kirundo and Calima were planted at ISABU Mosso for intercrossing. ISAR began a varietal crossing program in 1982 and first received segregating materials from CIAT this year. ISAR made more than 1000 individual selections from various crosses for further evaluation.

In addition, more than 100 bulk selections were made and passed into the essai triage and crossing blocks for intercrosses. Among these new breeding lines, many are from ISAR's first crosses made in 1982. Selections were made at all three of the major ISAR stations, Rubona, Karama and Rwerere representing three major ecological zones.

Diseases and pests. Diseases and pests are considered major limitations to increased bean production in the Great Lakes Region of Africa. Those most commonly observed and considered of economic importance are *Colletotrichum lindemuthianum*, *Isariopsis griseola*, *Ascochyta*/ *Phoma* spp. *Uromyces appendiculatus*, bean common mosaic Virus (BCMV). *Xanthomonas campestris* p. v. phaseoli, *Pseudomonas syringae* p. u. phaseolicola, and *Ophiomya phaseoli* and/or *O. spencerella* (bean fly). The program is, therefore, giving considerable emphasis to disease and pest control in collaboration with national institutions. Hundreds of lines have undergone preliminary evaluation for resistance and the best accessions are being used as parental materials in the breeding program. Table 177 presents several of the most promising materials which have remained symptomless or expressed only low levels of a disease without being highly susceptible to other pathogens and which were relatively well-adapted in the region.

In the 1984C season, 36% of the germplasm with resistance to BCMV expressed systemic necrosis, indicating that unprotected I-gene resistance is unlikely to be useful in this region. Results from the BCMV and I. griseola nurseries also indicate that the reactions of materials to these pathogens do not conform to reactions of identical materials over a number of locations in South America possibly indicating important race differences.

No anthracnose resistant lines could be identified in the last growing season due to lack of disease pressure. Consequently, various inoculation methods are being evaluated to facilitate the development of adequate levels of the disease in nurseries for disease evaluation. This season resistance nurseries have been planted and inoculated in Burundi, Rwanda and Zaire.

An investigation was begun in 1985A (September 1984 to January 1985) to determine the regional prevalence and distribution of pathogens and pests. In addition, the contribution to on-farm crop-loss due to pathogens and pests is being assessed relative to other production-limiting factors such as soil fertility. Concurrently, the reaction to diseases and pests are being evaluated in multilocational on-farm trials in two natural regions. Plans are being made to commence similar trials next season in Burundi and in Zaire.

The program is aware that the majority of farmers in the region add new bean varieties in various proportions to their mixtures. To date little is known about the effectiveness of resistant varieties in reducing disease when planted with farmers' mixtures. For this reason a study was begun to elucidate the effect of known proportions of resistance in mixtures on the development of disease.

An important objective has been the development of regional cooperation and distribution of pathology responsibilities between national institutes to optimize use of the available expertise for mutual benefit. One example of such cooperation is the regional disease/pest survey in Rwanda and Burundi which is being conducted jointly between ISABU and ISAR. Formal training so far has been restricted to the part-time supervision of a final year student from the Université Nationale du Rwanda and of a trainees from the Kivu region of Zaire.

Nutrition and quality research. According to a national nutritional survey conducted in Rwanda from 1967-1972, beans provide approximately 25% of the total caloric requirements, and 45% of protein needs. In Rwanda, Burundi and the Kivu region of Zaire, beans are the most important single contributer to protein requirements. The prolific population growth rate of about 3.5 % in the region should almost double the population in 20 years making the question of adequate food supplies a critical issue. The importance of increasing bean production is obvious since beans are the staple energy and protein source in the diet.

The main objective of nutritional research in the great lakes region is to evaluate the probability that a new variety will meet consumption criteria. Work was initiated in May 1984, and was focused on: developing a nutrition quality laboratory at ISAR Rubona; and conducting a survey about bean consumption and preferences in Rwanda.

a. Development of a nutrition quality laboratory. A lab - oratory for the evaluation of quality factors was established at ISAR, Rubona. Activities of the laboratory focus on the evaluation of advanced yield trials (essai comparatif) at ISAR. The purpose of this screening is to estimate the probalility that improved varieties meet consumption acceptability criteria. Following the methodology outlined in the CIAT Bean Program Annual Report, 1982, the evaluation of advanced lines has recently been initiated for: hardseed percent water absorption, of dry weight, cooking time, and spoilage after cooking.

In the future, emphasis will be placed upon evaluation of materials from the essai regional. The quality criteria evaluated will also be adapted as more information is gained about acceptability criteria.

b. Bean consumption and preference survey, Ruhengeri, Rwanda. The purpose of this survey was to identify preparation methods, and acceptability and preference criteria for bean leaves, green beans, immature dry beans, and dry beans. General information was also collected about meal patterns. This survey was conducted in the same location as the cropping system survey, in the northern prefecture of Rwanda called Ruhengeri. Five communes were sampled within the prefecture; three in the natural region of volcanic soils, and one in the relatively poorer soils of the highlands on the central plateau. Each of the communes varied in their elevation and cropping systems. Ruhengeri is the major potato-producing region where both climbing and bush beans are grown.

A total of 109 farmers were interviewed during July and August 1984. Since beans are harvested in July and planting does not begin again until September, few beans were in the ground during the time of the interviews. A broad range of family sizes were sampled. 56% of the families had between 2 to 5 members and 43% between 6 to 14 members. seventy-six percent of the respondents were female. Most of the respondents were classified as either adults (46%) or young (39%) although 14% were classified as elderly. Estimated farm sizes and soil fertility varied from small (29%), medium (51%), and large (20%), poor (4%), average (42%) and good (55%). Most respondents (84%) sell something for cash, a few possess cattle (18%), or work outside the home (13%).

Beans were identified as a favorite food by 81% of the sample. The order of preferences for various parts of the bean plant are dry beans, immature dry beans, green beans, and bean leaves, respectively. The most frequent explanation for dry bean preference was that "they swell", indicating the importance of an increase in volume after cooking.

Food is always prepared by a female, usually the mother (92%) sometimes the grandmother (5%) or daughter (3%). Covered earthen pots are usually used for cooking (98%), placed on top of three stones over a wood fire. Metal pots are sometimes used for reheating food. Dry beans are usually cooked 3(25%), 4 (26%) or 5 (21%) hours alone in boiling water. More water and salt are added while cooking. Dry beans are usually not soaked before cooking (86%) the most frequent explanation being that it is not necessary because beans do not take a long time to cook. Cooked beans are usually stored 2 (60%) or 3 (30%) days in the kitchen in an earthen pot. If the beans spoil, they are washed, boiled a second time, and then consumed.

Immature dry beans, green beans, and bean leaves were consumed by everyone in the sample. Green beans and bean leaves were often added raw on top of dry beans as they finish cooking or are reheated. Sometimes bean leaves and immature dry beans are cooked alone in boiling water. Immature dry beans and green beans are also often cooked together.

Certain varietal preferences were identified for immature dry beans, bean leaves, and green beans. All beans grown by farmers were acceptable for consumption as immature dry beans, although 82% indicated they preferred eating certain currently grown varieties more than others as immature dry beans. Most of the farmers interviewed (87%)indicated they prefer certain varieties for leaf consumption. Bush beans (78%) and earliness (89%) are preferred characteristics for green bean consumption.

Various culinary factors and preferences for dry bean consumption were identified. When asked whether they preferred eating a mixture or a single variety, most (53%) people had no preference (Table 178). This corresponds with observations of a small, inconsistent price differential in the market price of mixtures vs. pure varieties.

To identify the relative importance of various quality characteristics for which data was collected, it was assumed that the importance of a given characteristic is associated with the number of varieties identified for which it is unacceptable or preferred. The quality characteristics for which data were collected appear in Table 179 in order of importance. Not all of the five characteristics (for which at least 50% of the sample identified unacceptable varietal names) seem to be of relatively equal importance.

Although half of the respondents identified varieties with unacceptable cooking times, most people (66% and 73%, respectively), said they did not notice texture differences within a mixture of cooked beans.

Varietal preferences were identified for certain quality characteristics. Eighty-five percent and 72% of the sample identified varietal names which were preferred, respectively, for their general eating quality and color. A third of the sample named Mutiki, a large cream and red-mottled variety, for preferred color; and 20% cited Urushimandengo, a large, solid orange with a black hilum ring. These grain types represent only 14 and 9%, respectively, of the total number of varietal names cited for a preferred color. This indicates that color preferences exist, but, in contrast to Latin America, are quite diverse. 95% of the sample stated they have a seed size preference for which 92% preferred large grains.

Some general questions were asked concerning storage methods and seed quality after storage to evaluate whether the hard-to-cook phenomenon is a problem. Almost half (43%) of the sample stored seed for 1-3 months, while about a third (30%) stored seed between 4 - 6 months. This means most people (73%) stored seed from harvest to harvest. Most people observed changes in cooking time, eating quality, and color after storage, (Table 180), but few people could identify certain grain types which store better or worse than others. Of the people who identified unacceptable varietal names for cooking time after storage, 74% mentioned the variety Nyamukecuru (a small, solid kaki-colored variety). This variety was also cited for unacceptable eating quality and color change after storage. (Possibly named after it's quality characteristics, Nyamukecuru means old women in Kinyarwanda).

Most people (90%) indicated they occasionally try new grain types. 58% who try new grain types eat a sample of the seed before planting it. Sampling of seed before planting could be to assess eating and cooking quality before committing oneself, but also quite possibly because they had no more beans to eat, so, therefore, acquired a mixture of beans from the marketplace, a friend, or neighbor for consumption which contained new varieties that they planted later on.

Information about food habits was obtained using a 24 hour recall. The 24 hour recall is a standard dietary methodology used with large groups of individuals for providing a qualitative description of group dietary patterns. Information was obtained concerning the number of meals eaten per day, mealtimes, and foods commonly eaten per meal.

Fifty-nine percent and 34% of the sample eat 2 or 3 meals per day. Most people eat a meal in the morning (87%) and evening (78%). About half (58%) of the respondents eat at noon. Table 181 contains a list of food and beverages commonly eaten throughout the day. The majority of meals contain beans regardless of the time of day. Beans are most commonly eaten with potatoes. In contrast to the noon and evening meal, a beverage of caloric value is usually consumed in the morning. In general, selection of foods does not appear to change much throughout the day. With the consumption of traditional types of vegetables, fermented beverages, potatoes, and beans, the diet appears to be generally well balanced assuming that caloric needs are satisfied.

Agricultural production surveys. Farmers' bean production surveys have now been carried out in two regions of Rwanda - the central plateau and the volcanic soils section of Ruhengeri. Preliminary surveys have been started on the western slopes of the

Zaire Nile Crest in Gisenyi, Rwanda and Bujumbura, Burundi. The purpose of the surveys is to detail farmer production practices and diagnose production constraints and potentials of feedback to station research and to on-farm trials.

Subjects covered by the survey are: (1) crop rotation and association patterns, including the relative importance of the crop for each season and the most common associations in which beans are grown; (2) the division of labor for production tasks, including field preparation, seed selection, sowing, weeding, harvesting threshing and storage; (3) bean seed practices, including sources of seed, selection, storage and mixture management; (4) ranking of varietal selection preference criteria; (5) degree of experimentation with new varieties and seed multiplication of preferred varieties; (6) fertilizer and compost use; (7) disease and insect problems and methods of control; (8) ranking of major production constraints according to farmers's perceptions; (9) the extent of commercialization vs. home consumption of beans.

The statistics in the following section are derived from the Ruhengeri survey and are in agreement with the results of the more informal central plateau interviews.

a. Bean culture. Beans are almost always grown as mixtures (Table 182).

The great majority of farmers sow two to three discrete mixtures for different soils and associations Table 183.

Farmers practice a constant selection among varieties, which are consequently well-adapted to the micro-environments in which they are grown. There is also a high degree of experimentation with new varieties, which are incorporated into the mixtures if they prove acceptable (Table 184).

Farmer acceptability criteria are summarized in Table 185. It is noteworthy that yield and stability criteria are by far the most important and that grain color is of low importance. There is also decided preference for early varieties.

Most beans are grown in association with other crops' but significant areas of both bush and climbing beans are grown in monoculture. The most common associations for bush beans are: bananas, sweet potatoes, young cassava, low density maize, peas, taro and potatoes. For climbing beans they are: bananas, maize and sweet potatoes. When grown in association with maize, the climbers are usually staked, instead of using the maize as stakes. Farmers say this leads to higher yields of both crops and prevents lodging during storms. According to official estimates, and our observations, over 60% of all beans are grown in association with bananas.

Weed control is generally excellent, except in the steep slope regions of western Burundi, where farmers say the weeds help prevent erosion. No chemical fertilizers or pesticides are used; however manure or compost is applied if available. In practice, the fields near the houses are most heavily fertilized; however, manure/compost production falls critically short of needs (See Table 186).

Beans are virtually always planted randomly with an average measured plant density of about 300,000 plants per hectare. Planting is denser on poor soils and less dense on fertile soils. During the last, rather poor season, yields were measured on 16 farms. Yields varied greatly, from 200 -2,050 kg/ha, with an average of 650 kg/ha. National and World Bank statistics show an average country yield for Rwanda 0.78 and 0.8 tons/ha, respectively.

Women play a highly predominant role in agricultural production and a vritually exclusive role in seed selection and seed storage. (Table 187). This indicates that on-farm variety trials and distribution of improved seed must focus on women if these activities are to have the desired impact.

Although many farmer practices may limit diseases eg. rotations, associations, mixtures, removing plants from the field at harvest etc. -farmers conceptual knowledge of diseases is limited. When shown a plant with strong disease symptoms they will almost always attribute the problem to too much sun or too much rain. Thus, the questions on the extent of disese damage produced unuseable data. The pathologist has consequently started fiel observations to measure this factor.

Insect damage, on the other hand, is much better understood with the exception of the beanfly (Ophiomya sp.) which can cause considerable damage during dry periods. All farmers interviewed considered insect attacks to be an important factor in reducing their yields Table 188.

Presently, and for the future, the interviews are being continued in different parts of the region, corresponding to major agro-social differences among different zones within the region. Emphasis is also being placed on multiple visit interviews with farmers hosting on-farm trials, to evaluate cyclical and longitudinal patterns and to assess the acceptability of new varieties and technologies proposed by the research.

Future plans

Research and other activities of 1984 will be continued through 1985 with additional emphasis on the development of a network of on-farm trials throughout the region to test promising varieties and on the feedback of information on production constraints to varietal development programs. A large number of on-farm trials have in fact been recently planted on the Rwandan central plateau and Nile-Zaire Crest and will be harvested in late 1984 and early 1985. Additional on-station trials will also be initiated, especially, uniform regional disease nurseries to identify adapted parental lines and varieties that are resistant throughout the region. Additional emphasis will also be placed on varietal development for low fertility soils, high soil acidity and drought-prone regions marking the importance of bean production throughout the region including those areas with often severe edaphic constraints. Additional emphasis will also be placed on development and expansion of climbing bean technology that promises large yield increases in this typically labor-intensive cropping system. Lastly, emphasis will increasingly be placed on training in the form of visits to CIAT and regional research and production workshops. The latter will especially be a key factor in the development of a network of intercooperation within the region.

Table 171. Germplasm originating at CIAT evaluated in the Great Lakes Region in 1984.

Location	International yield trials	Advanced lines	Segregating populations
ISABU (BURUNDI)			
1984 A[a]	3	68	0
1984 B	5	582	65
ISAR (RWANDA)			
1984 A	8	913	223
1984 B	5	481	154
INERA (ZAIRE)			
1984 B only	3	48	0
TOTAL	24	2092	442

[a]1984 A: January harvest, 1984 B: June harvest.

Table 172. Description of primary research stations in the Great Lakes Region.

Primary research stations	Elevation msl	Mean temp. °C	Mean rainfall mm/yr
Burundi (ISABU)			
Mosso	1260	22.1	1200
Kisozi	2090	16.7	1425
Murongwe	1470	20.0	1400
Rwanda (ISAR)			
Rubona	1650	19.2	1200
Karama	1300	20.8	875
Rwerere	2100	15.5	1150
Zaire, Kivu Region (INERA)			
Mulungu	1730	16.2	1845
Ndihira	2190	15.0	1250

TABLE 173: Number of varieties introduced from CIAT and evaluated at ISAR, RWANDA, (1982-1984).

Harvest year	Number of varieties
1982[a]	67
1983	884
1984	1394

[a] Cropping year begins with the October planting of the previous year.

Table 174. No. of adapted bush and climbing bean lines and varieties originating from CIAT in advanced evaluations at ISAR, Rwanda. Sept. 1984 plantings.

Lines	No. varieties
(1) Second level screening (essai triage)	200
(2) Third level screening (essai comparatif)	45
(3) Multilocation adaptation trials.	9
Varieties Tested	
A 197 V 79116	
Ica Palmar G 2333	
Calima G 685	
G 858 G 811	
Ica Viboral	
4) On farm trials	
Varieties Tested	
Ica Palmar	
V 79116	2

Table 175. Yields (kg/ha) of the five best varieties from the Mexican highland IBYAN (group 45.000) and their control varieties at each of six sites in the Great Lakes Region in the 1984B cropping season.

Isabu, Imbo	860 msl	Isabu, Mosso	1260 msl	Isabu, murongwe	1470 msl
Carioca	738	Carioca	1501	A 411	1371
A 344	852	A 114	1481	A 344	1210
A 409	782	BAT 1671	1493	A 114	1197
A 442	619	A 439	1436	Carioca	1110
A 321	616	A 344	1392	BAT 1671	1098
Control Varieties					
Calima	274	Calima	1402	Urubonobono	1150
Karama	176	Karama	1399	Local mixture	833

INERA, Mulungu	1731 msl	ISAR, Rubona	1650 msl	ISAR, Karama	1300 msl
A 321	1877	A 442	2233	A 439	1760
A 344	1886	A 410	2207	A 410	1710
A 262	1817	BAT 1671	2183	A 321	1660
BAT 1671	1785	A 344	2143	A 411	1490
A 439	1727	A 321	2120	A 436	1490
Control Varieties					
Munyu	701	Rubona 5	1910	Ikinimba	1450
Muhinga	890	Ikinimba	1513	Var	1380

TABLE 176. 10 best climbing bean varieties in ISAR Rwerere advanced yield trial (essai comparatif), Sept 1983 planting, 1984A.

Identification	Country of origin	Source	Average yield kg/ha
G 858	Mexico	CIAT	6,407
ICA VIBORAL	Colombia	CIAT	5,298
C 8	Zaire	Zaire	4,876
G 811	Mexico	CIAT	4,859
G 2373	Mexico	CIAT	4,854
G 2333	Mexico	CIAT	4,840
G 11820	Colombia	CIAT	4,698
C 10	Zaire	Zaire	4,590
URUNYUMBA 3	Rwanda	Rwanda	4,534
GISENYI 6	Rwanda	Rwanda	4,047
Cajamarca (Control)	Peru	Gembloux	4,812

TABLE 177. Varieties with no or few symptoms to indicated diseases in the Great Lakes Region, Africa.

Colletotrichum lindemuthianum	G. H.[a]	*Isariopsis griseola*	G.H.	Ascochyta Spp.	G.H.	BCMV (symptomless)	G.H.	*Pseudomonas syringae*	G. H.	*Xanthomonas campestris*	G.H.
A 483	I	A 240	II	GUAT 196-B	IIIB	G 4449	I	BAT 1220	IIIA	XAN 42	IIIA
A 484	I	A 281	II	V 8010	II	G 7587	I	G 790	IVA	XAN 112	II
AB 136	IIIB	A 337	II	BAT 1225	II	A 480	I	Red Kote	I	XAN 125	II
Ecuador 299	IIIB	A 338	II	BAT 1486	II	A 482	I			BAT 1336	II
7920	IIIA	A 340	II	VNA 81006	IIIB	BAT 1373	I			BAT 1449	II
		BAT 431	II	VRA 81022	IIIB	BAT 1386	I				
		BAT 1432	II			PAD 41	I				
		BAT 1435	II								
		BAT 1510	II			PAD 43	I				
						PVA 721	I				
						PVA 783	I				
						PVA 1216	I				
						ORFEOINIA	I				

[a] G. H. = Growth habit

TABLE 178. Preference in Ruhengeri Rwanda for consuming beans as a mixture or a pure variety.

Preference	% of respondents	Most cited explanation	% of respondents
No preference	53		
Mixture	33	Cultivate mixtures	78%
Pure	15	Different varieties have different cooking times.	86%

TABLE 179. Culinary criteria for which unacceptable varietal names were identified, in Rubengeri, Rwanda.

Culinary criteria	% of respondents
Broth quality	64%
Water absorption/swelling	60%
Eating quality [a]	57%
Cooking time	54%
Conservation after cooking	52%
Testa intact after cooking	17%

[a] Eating quality is a general term which includes flavor, aroma, mouthfeel, texture, etc.

Table 181 : Beverages and consumption of beans in the morning, noon and afternoon/evening meals.

TIME OF DAY	% OF MEALS CONTAINING BEANS	% OF MEALS BEANS ARE EATEN ALONE	MOST COMMON BEAN ACCOMPANIMENTS	% OF RESPONDENTS	BEVERAGES	% OF RESPONDENTS
Morning	90	8	Potato	32	Sorgum porridge	68
			Vegetables	12	Banana wine	14
			Green bananas	12	Sorgum beer	18
Noon	91	6	Potato	41	Water	57
			Green bananas	27	Sorgum beer	18
			Sweet potato	14	Banana wine	10
					Sorgum porridge	7
Afternoon/ Evening	79	11	Potato	39	Water	55
			Green bananas	15	Sorgum beer	20
			Vegetables	15	Banana beer	14
			Sweet potato	15	Banana wine	4

TABLE 180. Observed change in cooking time, eating quality, and color after storage in Ruhengeri, Rwanda.

Quality factor	% of respondents noticing changes	% of respondents who identified unacceptable varietal names
Cooking time	98	37
Eating quality	63	24
Color	57	18

TABLE 182. Motives and percentages of mixture preferences from the agricultural production surveys in Ruhengeri, Rwanda.

Practice:		Explanation:	
Prefer to sow mixture[a]	Prefer to sow single variety	Mixture has better yield	Mixture more stable yield
96%	4%	61%	67%

a 100% Multiple Responses

TABLE 183. Number and type of different mixtures sown in Rubengeri, Rwanda.

No. of mixtures				Planting conditions			
1	2	3	4	Poor soil	Good soil	Banana association	Other
9%	37%	51%	3	61%[a]	65%	45%	14%

[a] 100% due to multiple responses

TABLE 184. Use of new varieties in Rubengeri, Rwanda.

Never try	Try sometimes	Try often	Try separately	Try mixed	Save for seed if good	Multiply for seed if good
8%	52%	40%	--	--	96%	96%

TABLE 185. Farmer's ranking of varietal selection Criteria in agricultural production surveys in Ruhengeri, Rwanda.

IMPORTANCE		ATTRIBUTE		SCORE MAX 100	
Very important		Yield		92	
		Rain tolerance[a]		85	
Important		Drought tolerance		76	
Medium Importance		Eating quality		60	
		Strong upright		48	
Low importance		Storability		36	
		Fast cooking		31	
		Green bean quality		29	
		Leaf quality		20	
Negligible importance		Grain color		6	
Prefer early varieties	78%	Prefer middle varieties	12%	Prefer late varieties	10%

[a]: Farmers usually consider rain and drought tolerance to include resistance to diseases and insects associated with these conditions. A strong upwright stem is associated with rain resistance as farmers prefer varieties that do not lodge during the heavy downpours common in Ruhengeri.

Table 186. Extent of Manure/compost availability in Rubengeri, Rwanda.

All fields	3/4 of fields	½ of fields	¼ of fields
6%	16%	33%	45%

TABLE 187. Bean production tasks by gender in Ruhengei, Rwanda

	Prepare field	Sow	Choose seed	Weed	Harvest	Thresh	Seed storage
Always[a] Woman	82%	100%	100%	100%	88%	68%	100%
Sometimes[a] Woman	18%	-	-	-	12%	32%	-
Always[a] Man	32%	-	-	-	8%	36%	-
Sometimes[a] Man	64%	2%	-	10%	40%	50%	-
Never[a] Man	4%	98%	100%	90%	52%	14%	100%

TABLE 188. Farmers perceptions of extent of insect damage in Rubengeri, Rwanda.

Little damage	Medium damage	Serious damage	¼ of field affected	½ of field affected	Whole fields affected
4%	45%	5%	50%	46%	4%

7. Collaborative Bean Research at IVT, Wageningen, Netherlands.

1. Incorporation of resistance genes into CIAT breeding lines

The A. program with IVT 7233 x IVT 7214. Ten lines of F_3B_2 CIAT progenitor x F_3 (IVT 7233 x IVT 7214), which had been selected in 1983 for resistance to all strains of BCMV and the most agressive strain of BYMV, were brought to CIAT in January 1984 to make the next backcross generation. However, the CIAT breeder was informed that some susceptibility to BYMV was observed in some lines, and that he would be advised about the lines with the best resistance later on during the year.

The symptoms observed in the lines, supposed to be resistant to the most agressive strain Tn of BYMV, occurred for the first time in an experiment made at the end 1983, and were found in all lines. They develop late, about three weeks or more after inoculation, and show a mild mottle without stunting of the plant. The symptoms with this strain in the control varieties are already severe after 7-10 days. This was a new development, as the lines must carry gene bc-3, proved by test-cross analysis, which has given a complete resistance to the virus so far. No contamination of the virus could be detected and the virus was again identified as BYMV on a series of indicator species. The tentative conclusion is that the agressiveness of the Dutch Tn strain of BYMV has increased.

The symptoms developed only in part of the plants of the various F_3 lines, and back-inoculations onto 2 or 3 plants of the very sensitive variety Widusa did not reveal systemic virus spread in all plants. F_4 seeds were harvested from the virus-free plants and tested in successive experiments. The results were about the same as in the tests of the F_3 materials: mild and retarded symptoms developing in part of the plants or in all plants of each line. The selection was continued to F_5, but no line could be selected in which all plants were virus-free.

To investigate whether the older materials, viz. the first crosses with CIAT progenitors (B_o), and the first backcross (B_1) had some complete resistance left, all the lines in F_3, F_4 and F_5. (if seed were available) were tested. The materials did not yield completely resistant lines. These test results contrasted with those of experiments in 1980 and 1981, in which the lines were selected for their complete resistance to BYMV.

In conclusion: the breeding lines of Program A, which are still completely resistant to BCMV, and were selected in 1981 and 1982 for their simultaneous resistance to BYMV, are at present no longer completely resistant to the present Dutch isolate of the Tn strain of the latter virus. However, they might still be completely resistant to the strains of BYMV occurring in other countries and other continents.

The question remains whether the source of this BCMV/BYMV resistance, lines of IVT 7214, are still resistant to the Tn strain. No symptoms were observed in lines of IVT 7214, used as controls in the 1984 experiments. But back-inoculation onto Widusa plants showed the presence of virus in some plants. More back-inoculations will be made in on-going experiments.

The inheritance of the resistance in IVT 7214 to the Tn strain is being studied in on-going experiments, in which F_2 populations of crosses between IVT 7214 and Widusa and Topcrop are analyzed.

The B. program with IVT 7620. Testing of the Program B materials has been done on a more limited scale this year because of the large-scale testing in different generations of Program A materials, and the continuous selection in that program. One experiment was completed and two other ones have not yet been finished. The problems of slight susceptibility to Tn strains of BYMV were also revealed in Program B materials, but they do not seem as generalized as in Program A. More experiments have to be done before conclusions can be drawn. The results will be given in an interim report next spring.

2. Testing of CIAT breeding lines for resistance to BCMV lines for the Andean highlands and Mexico. Some 136 breeding lines were screened with BCMV-NL3 + NL5. Detailed information was already sent to the CIAT breeding program. Four out of sixty CO.B3 numbers carried the dominant I gene (one not uniform). Almost every one from the 66 PV AD numbers had II, and two out of the ten Mexican PV MX numbers also had II.

Very often a Tn (top necrosis) reaction was obtained, especially in the Andean numbers. It looks like systemic necrosis, but is basically different in that in occurs with some strains only in ii-genotypes, especially when the normal mosaic symptom is induced with difficulty. However, top necrosis and mosaic may be seen simultaneously in the same plant. This never occurs with systemic necrosis and mosaic, if both are induced by BCMV. A plant with top necrosis is sometimes killed by wilting through necrosis of the main stem, but does not show the abundant pinpoint lesions and vein necrosis in the leaves, which occurs in a plant with systemic necrosis and the I gene. Most plants with top necrosis easily drop their leaves, starting with the lowest ones. This description is given as many researchers have difficulties in distinguishing plants with systemic necrosis (II) and those with top necrosis (ii).

Testing advanced lines for the Andean highlands. Thirty-nine advanced lines of type CO.B3 and 19 accessions of Bean Breeding I were tested with BCMV strains NL3, NL5 and NL4 to confirm the presence of gene I and to detect additional recessive genes like $bc\text{-}1^2$, $bc\text{-}2^2$ or bc-3. Genes bc-1 and bc-2 are not detected with these strains but are not important for the breeder.

A few lines with II have a red or purple-mottled seed color. One of them (CO.B3 39) seems to have an acceptable red-mottled color. This one might be important in view of the linkage between red-mottled seed and ii. Gene $bc\text{-}2^2$ was not present. Two numbers were heterogenous for the I gene. One did not produce symptoms with any of the strains. (It must have bc-3 from the crossing with IVT 80338.) Two numbers carry the genes I $bc\text{-}1^2$.

3. Selection for resistance to Xanthomonas

Selections for resistance to Xanthomonas were made in the F_3B_2 populations of the species-crosses between *P. vulgaris* and *P. acutifolius* made in the University of California at Riverside.

The frequency of resistant plants in F_3B_2 populations was low but not unexpected, as no selection for resistance had been done before, and *P. acutifolius* had already been crossed three times with *P. vulgaris*. Most F_4 lines from the F_3 plant selections segregated. The selected F_5 lines will be tested for uniformity in 1985. Seven XAN lines were received from CIAT, derived from the same *P. acutifolius* crosses from University of California at Riverside, and they were tested for uniformity of resistance. Six were still segregating, and new plant selections were made. Crosses were made between XAN 159-1 and CIAT lines ARBF 45 (large, white seeds), ARBF 848 (medium large white seeds), and A 441 (Ojo de Cabra seed type). The F_2 will be used in 1985 to study the inheritance of resistance in *P. vulgaris*.

Crosses were made between *P. acutifolius* accessions PI 319.443 (R) and Oaxaca 88 (S), and between PI 319.443 (R) and PI 313.488 (S) to study the inheritance of resistance within *P. acutifolius*. The F_2 generation of these crosses is now being tested.

Plant selections with resistance to Xanthomonas were also made in the F_3B_1 of the *acutifolius* crosses. The F_4/F_5 lines will be tested for uniformity of resistance in 1985.

Crosses were made between IVT selections from the F_3B_2 *acutifolius* crosses and the Dutch varieties Belami and Remora, resistant to *Pseudomonas*, for combining the resistance to both bacterial diseases. Belami has better resistance than Wisconsin HBR 72, mentioned in the Bean Program Annual Report of 1983; the leaf resistance of the latter is better than in Belami, but the pods are susceptible.

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* Left during 1984.

APPENDIX I. List of associated centers and institutions

CARDI	Caribbean Agricultural Research Development Institute, West Indies.
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.
CDA	Collaboration for Development in Africa.
CENARGEN	Centro Nacional de Recursos Genéticos, Brazil.
CENICAFE	Centro Internacional de Café, Colombia.
CENTA	Centro Nacional de Tecnología Agropecuaria, San Salvador, El Salvador.
CGIAR	Consultative Group for International Agricultural Research, New York, New York.
CGPRT	Course Grains, Pulses, Roots and Tuber Crops Center,
CIAB	Centro de Investigación Agrícola del Bajío, México.
CIAGOC	Centro de Investigación Agrícola del Golfo Centro, México.
CIANOC	Centro de Investigación Agrícola Norte Central, México.
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Londres, México.
CIP	Centro Internacional de la Papa, Lima, Perú.
CNP	Consejo Nacional de Producción, Costa Rica.
CNPAF	Centro Nacional de Pequisa em Arroz e Fejiao, Brazil.
CIPA	Centro de Investigación y Promoción Agropecuario (I and II), Perú.
CPATU	Centro de Pesquisa Agropecuaria de Trópico Umido, Brazil.
CRSP	Collaborative Research Support Program, Tanzanía

CVC	Corporación Autónoma Regional del Valle y Cauca, Colombia.
DIGESA	Dirección General de Servicios Agropecuarios, Guatemala.
DRI	Desarrollo Rural Integrado, Colombia.
EEAOC	Est. Exptl. Agrícola Obispo Colombres, Brazil.
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brasilia, Brazil.
EMCAPA	Empresa Capichaba de Pesquisa Agropecuaria, Brazil.
EMGOPA	Empresa Goianía de Pesquisa Agropecuaria, Brazil.
EMPASC	Empresa de Pesquisa Agropecuaria de Santa Catarína, Brazil.
EPABA	Empresa de Pesquisa Agropecuaria de Bahía, Brazil.
ESAL	Escola Superior de Agricultura de Lauras, Brazil.
FAO	Food Agricultural Organization of the United Nations, Rome, Italy.
FEDECAFE	Federación Nacional de Cafeteros, Colombia.
IAPAR	Fundação Instituto Agropecuario de Paraná Brazil.
IAR	International Agricultural Research.
IARC	International Agricultural Research Centers Network.
IBPGR	International Board for Plant Genetic Resources, Rome, Italy.
ICA	Instituto Colombiano Agropecuario, Colombia.
ICARDA	International Center for Agricultural Research in the Dry Areas, Beirut, Lebanon.
ICTA	Instituto de Ciencia y Tecnología Agrícola, Guatemala. Cita, Guatemala.
IDIAP	Instituto de Investigaciones Agricola Panameñas, Panama.

IICA	Instituto Interamericano para la Cooperación Agrícola, Costa Rica.
IITA	International Institute of Tropical Agriculture, Nigeria
INCAP	Instituto de Nutrición de Centroamérica y Panamá, Costa Rica.
INERAL	Institut Nacional des Etudes es Rechervhes Agrícolas, Zaire.
INIA	Instituto Nacional de Investigación Agrícola, Perú.
INIAP	Instituto Nacional de Investigaciones Agropecuarias, Ecuador.
INIPA	Instituto Nacional de Investigaciones y Promoción Agraria, Lima, Perú.
INRA	Institut Nacional de Recherches Agronomiques, Guadalupe.
INTA	Instituto Nacional de Tecnología Agropecuaria, México.
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina.
INTA	Instituto Nicaraguense de Tecnología Agropecuaria, Nicaragua.
IPA	Instituto de Pesquisa Agropecuaria, Pernambuco, Brazil.
IPAGRO	Instituto de Pesquisas Agronómicas, Brazil.
ISABU	Institut de Sciences Agronomiques du Burundi, Burundi.
ISAR	Institut Scientifique et Agronomique du Rwanda, Rwanda.
ISNAR	International Service for National Agricultural Reserach, The Hague, Netherlands.
IVT	Institut Veredeling, Tuinbouwge, wassen, Holland.
PCCMCA	Programa Cooperative Centroamericano de Mejoramiento de Cultivos Alimenticios.

NUMBER	IDENTIFICATION	LOCAL REGISTER	ORIGEN	SOURCE	SPECIES	SUBSPECIES
6798	Nicaragua 13	HDR-1064	NCA	HDR	VUL	V
7050	Nicaragua 22	HDR-1073	NCA	HDR	VUL	V
7099	Lila	HDR-1354		HDR	VUL	V
7120	Feicas Bico Rojo Precoz	HDR-2631	BZL	HDR	VUL	V
7169	Peru 23	HDR-1156	PER	HDR	VUL	V
7791	Gua.2226-B-21-N-0-2226(3C	HDR-2079	GTA	HDR	VUL	V
7796	Honduras 92	HDR-0712	HDR	HDR	VUL	V
7844		HDR-0396	GTA	HDR	VUL	V
7895	Peru 40	HDR-1160	PER	HDR	VUL	V
8042	Glp 1=Renka		KYA	KYA	VUL	V
8142	Amarillo 169		MEX	MEX	VUL	V
8252	Guatemala 445	HDR-0517	GTA	HDR	VUL	V
8314	Guatemala 0064	GTA-0064	GTA	GTA	VUL	V
8565	Guatemala 0503	GTA-0503	GTA	GTA	VUL	V
8590	Guatemala 0547	GTA-0547	GTA	GTA	VUL	V
9594	Guatemala 708	GTA-708	GTA	GTA	VUL	V
10000	Guerrero 924	NI-406A	MEX	BLG	VUL	R
10010	Morelos 636	V-1430	MEX	UTK	VUL	M
10010 A	Morelos 636	V-1430	MEX	UTK	VUL	M
10011	Morelos 637	V-1431	MEX	UTK	VUL	M
10019	Michoacan 1002	V-1407	MEX	UTK	VUL	M
10019 A	Michoacan 1002	V-1407	MEX	UTK	VUL	M
10020	Michoacan 1009		MEX	MEX	VUL	M
10022		P1319441				
10025	P. Aborigineus		ARG	ARG	ABO	A
10477	Guatemala 892 (Bolonillo)	GTA-0892	GTA	GTA	VUL	V
10539	Guatemala 956	GTA-0956	GTA	GTA	VUL	V
10813	Guatemala 1240	GTA-1240	GTA	GTA	VUL	V
10816	Guatemala 1243 (Bolonillo)	GTA-1243	GTA	GTA	VUL	V
10889	Guatemala 1382	GTA-1382	GTA	GTA	VUL	V
11027		DGD78/082	MEX	MEX	VUL	R
11027		DGD78/082	MEX	MEX	VUL	R

NUMBER	IDENTIFICATION	LOCAL REGISTER	ORIGEN	SOURCE	SPECIES	SUBSPECIES
11056		DGD78/148	MEX	MEX	VUL	M
11820	Linea 32980-M(4)-MA-M-M		CLB	CLB	VUL	V
11821	Linea 32980-M(8)		CLB	CLB	VUL	V
12733	San Rafael de San Pedro		CRA	CRA	VUL	V
12861		PI318692	MEX	USA	VUL	M
12880	Del raton	PI325687	MEX	USA	VUL	M
12885	Silvestre 1	PI346955	MEX	USA	VUL	R
12886	Silvestre 3	PI346956	MEX	USA	VUL	M
12891		PI417624	MEX	USA	VUL	M
12895		PI417628	MEX	USA	VUL	R
12907		PI417643	MEX	USA	VUL	R
12929	Coyote	PI417691	MEX	USA	VUL	R
12942		PI417706	MEX	USA	VUL	R
12946		PI417711	MEX	USA	VUL	R
12948		PI417774	MEX	USA	VUL	R
12949		PI417775	MEX	USA	VUL	R
12952		PI417778	MEX	USA	VUL	R
12953		PI417780	MEX	USA	VUL	R
12954		PI417781	MEX	USA	VUL	R
12955		PI417782	MEX	USA	VUL	R
12979	M7439T		MEX	USA	VUL	M
13022	Rio San Lorenzo 11	V-1481	MEX	UTK	VUL	M
13614	De Celaya	X-16162	MEX	MEX	VUL	V
13936	Don Timoteo		SPN	CLE	VUL	V
14233		PI415952	PER	USA	VUL	V
14513	Mezcla Roja selec.30	HDR-2085	GTA	HDR	VUL	V
15423	Cuarentano		MEX	MEX	VUL	V
15423 A	Cuarentano		ELS	MEX	VUL	V
15427	507 1913	BZL-0852	BZL	BZL	VUL	V
15818	Sangretoro (Potosi)		CLB	CLB	VUL	V
35182	Guatemala 1076 (Piloy)	GTA-1076	GTA	GTA	COC	P
40020		PI319443	MEX	USA	ACU	L
40034	Nayarit 13B		MEX	MEX	ACU	L
40111		DGD78/587	MEX	MEX	ACU	L

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