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Bean Program Annual Report 1982

Centro Internacional de Agricultura Tropical, Apartado 6713, Cali, Colombia

Contents

Highlights 1982

Until 1981 the Bean Program made most of its impact in those countries which make a relatively small contribution to total bean production in Latin America. In 1982 concrete results became evident of the progress achieved in the bean research network in the three largest bean producing countries of Latin America: Brazil, Mexico, and Argentina.

After some years of testing in Brazil, two IBYAN entries, BAT 64 and BAT 65 called Rico 1735 and Milhionarios 1732, respectively, were released as new varieties. These new varieties were chosen for superior yield performance and increased disease resistance in the Minas Gerais region. Two other lines BAT 304 and BAT 179 may also be released in the future. Probably of greater importance, however, is the extensive testing of over 500 newly developed lines from CIAT in six sites in Brazil. The transfer of Dr. M. Thung from CIAT to the National Center for Bean Research in Brazil (CNPAF) has been instrumental in this development.

In Mexico the bean golden mosaic virus problem has increased in importance over the years and the traditional variety Jamapa has not withstood the virus. The new BGMV resistant line D-145 (DOR 60) has been introduced and released as Negro Huasteco 81. The development of this line illustrates the operational philosophy of the Bean Program in its network. The cross resulting in Negro Huasteco 81 was made in CIAT in the BGMV resistance breeding project. The line was initially selected by ICTA in Guatemala in a collaborative program with CIAT, and final selection and varietal release was made by INIA, Mexico. This illustrates significant progress towards the team objective of decentralizing research through training, network formation and collaborative projects with national programs. Over 100 tons of foundation seed is expected to be available by the end of 1982.

Argentina is the third largest bean producer in Latin America. The recent very severe outbreak of bean chlorotic mottle virus and the aggravation of traditional disease pressure have resulted in massive multiplication of DOR 41 (= ICTA Quetzal), another line developed in collaboration with ICTA in Guatemala in the BGMV project. The line proved to be resistant to the BCLMV as well, which is also whitefly transmitted. It was tested extensively over 3 years and showed besides BCLMV resistance, high yield and uniform grain type. It was officially released as a new variety. This line, together with BAT 304, EMP 84, BAT 7, BAT 76, and BAT 448, all CIAT lines, are expected to cover all black bean production in Argentina in 1984. Improved Alubia's are expected to have a major impact in 1986.

CIAT has an excellent relationship with the host country's agricultural research programs of ICA. Out of the ICA-CIAT collaborative research project for beans a climbing bean line E1056 has been introduced, tested and officially released as ICA-Llanogrande. The new variety is adapted from 1700-2700 masl. Its superiority is based on resistance to anthracnose and, being a less aggressive climber, is more compatible with the small farmer system of relaying beans with maize. By the end of 1982 approximately 3 tons of seed will have been distributed.

Similarly, new varieties were released in Ecuador, Costa Rica, and Honduras. The first varietal releases also occurred in Africa where South Africa released BAT 317 and Burundi released the Colombian variety Diacol Calima, which reached them via CIAT's IBYAN trials.

Not only were CIAT varieties released in Brazil and Mexico for the first time (these two countries accounting for approximately 80% of total Latin American bean production) but also large nurseries of newly developed lines and parental sources were planted in collaboration with national programs in several sites in these countries for the first time. It appears that in Brazil the angular leaf spot race complex and in Mexico that of anthracnose are distinct from those occurring at CIAT testing sites and now we use parents with proper resistance sources for these countries, as well as better parents with local adaptation.

Another important development is noticed by the change in training emphasis. In previous years short courses and postgraduate interns were principally carried out at CIAT, but in 1982 most training activities took place in the collaborating countries. Following CIAT training and collaboration, new varieties were released in many countries, and in-country courses were organized around these new varieties. Such courses took place this year in Costa Rica, Cuba, Honduras, and Guatemala, while in Brazil and Peru CIAT-sponsored courses were conducted which were not related to new varietal releases. A total of four courses were also conducted in Colombia, one of these around the release of ICA-Llanogrande. The other courses involved personnel from ICA, Federación Nacional de Cafeteros, and the CVC in preparation for the execution of regional trials, small farm seed multiplication and improved agronomy. In these trials bush bean lines like BAT 1297 continue to outyield Calima by 60%, while two new highly promising climbing lines for lower altitudes were identified (V8036 and V8038). This development illustrates that the collaborative network has entered the phase following varietal development, namely the promotion of these new varieties.

Research results at the headquarters continued to show progress. Most activities in 1982 again involved use and incorporation of results and methodologies developed before. Most important, new developments during 1982 follow.

It has been observed for some time that certain bean lines have field tolerance to anthracnose which is not manifested in the screenhouse trials. It appears that seedlings are often susceptible but that plants three weeks or older have much higher resistance. This significantly influences screening methodology and may lead to detection of more stable resistances. Similarly, in rust resistance certain pathogen reaction types, although showing high disease incidence, did not influence grain yields. In previous years the difficulty of obtaining BCMV resistance (I gene) in certain grain types was discussed. While this continues to be difficult for the Canario (yellow) grain type, indications are that it is now possible to incorporate this resistance in the red mottled Calima grain types. The sources with high levels of resistance encountered and reported last year to *Apion* and Bruchid attack are now being crossed to commercial cultivars and their progenies are undergoing evaluation.

Following two intensive dry seasons new increased drought tolerant sources were identified. The line G 5059 was one of the most drought tolerant of all bush lines tested, but it was surpassed in tolerance by many climbing bean lines. We attribute this surprising finding to the high leaf area index of climbers, permitting better root development.

The Program

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

To set out a strategy to reach the above objective the team reviewed the literature, travelled in the area of interest (current bean production zones in Latin America with expansion in the eighties into Africa), has consulted with national program research leaders and research scientists, and has conducted an agroecological survey. From this information it became evident that the principal bean farmer is a small farmer with limited capital and limited access to credit and extension information. Bean yields are low and trending downwards in many countries. The main factors responsible for the low yields were the high disease and insect pressure the crop suffers from, as well as drought, low plant density to avoid disease pressure, and reluctance on the part of farmers to use fertilizers on poor soils due to risk.

The team concluded, therefore, that in order to reach its objectives, it should prioritize breeding for more reliable yielding beans, by developing multiple disease and pest resistant varieties with increased tolerance to drought. Longer term objectives include tolerance to moderately acid soils and improved genetic ability for symbiotic nitrogen fixation. In summary the team concluded that the key to improved bean production is an improved variety. Around this superior variety improved agronomy will be applied. The team develops scale neutral technology, with a bias towards small farmers.

New bean varieties, besides being superior yielders at the farm level, also need to convey the proper seed size and seed coat color, and they must fit into farmers' production systems, which often include maize in direct association or relay cropping. These requirements often preclude the use of the most disease resistant and highest yielding varieties.

As we have to breed for many cropping systems and ecological zones it is evident that a decentralized breeding program is needed, which can only be achieved through a concentrated training effort; hence training is our second most important activity after varietal improvement.

The Bean Program has three breeders, whose responsibilities are divided by production region. That automatically includes a division by color and seed size, priority disease complex, and often by cropping system. So, although we need to breed for a complex set of requirements as a whole, each breeder concentrates only on a subset. The three regions and breeding programs are: Breeding I: Central America, Caribbean Coastal Americas, and Southern Brazil; Breeding II: Mexican highlands, North and North-East Brazil and Argentina; and Breeding III: Andean Zone and Africa.

Genetic variability for specific traits in beans is generally not expressed at levels sufficiently high to solve production constraints. Therefore each breeder, besides developing cultivars also cooperates with the particular discipline to develop maximum levels of character improvement e.g., BGMV resistance, drought, 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 expression are then used by all breeders for obtaining multiple factor recombinants in the cultivar improvement activities.

Once a newly developed line from the improvement program is found superior, uniform for character expression, plant and grain type, and resistant to BCMV, it enters the first uniform evaluation nursery - the VEF (Vivero del Equipo de Fríjol). In this nursery approximately 1000 entries are evaluated for disease and insect resistance and adaptation to Palmira and Popayan environments. Superior entries may enter again into the breeders crossing blocks as parents, and may pass to the second stage of evaluation - the EP (Ensayo Preliminar de Rendimiento) 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 realized outside Colombia, and that part of EP nursery with grain types of specific interest to particular national programs is provided upon request.

The 60 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. All three nurseries run from January 1st. to December 31. National programs are encouraged to offer their best hybrid lines into this open testing procedure, to provide horizontal transfer of technology.

The EP and IBYAN however, are not the only nurseries shipped internationally. International disease or insect resistance nurseries are shipped to identify race complexes of pathogens in target areas as well as donors for wide resistance. The crossing blocks are sent to a production zone in the target area to select for specific adaptation in parental material. Similarly, international nurseries exist for nitrogen fixation (for strains as well as bean lines) and diseases and insects not occurring in Colombia. The program is increasingly developing segregating populations and early generation progenies to be evaluated by interested breeders and outreach programs.

From the above philosophy it is clear that the program has a strong emphasis on 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. The addition of the cropping systems agronomist (on-farm research) is instrumental in this concept, and assures that breeders are familiar with systems into which new varieties must fit.

After genetic improvement, the Program has given high priority to training. Self-reliance in research at the national program level is our eventual goal. The diversity of cropping systems, production constraints and consumer requirements also makes it impossible for CIAT to attend all. The results of such training are becoming visible and show an evolution in our training strategy: the EP was exclusively a CIAT nursery, but it is now an international nursery. Decentralized selection from the F_2 generation on, is becoming increasingly important. CIAT-hosted courses are being replaced by in-country courses. The Team expects that through post graduate training, leadership and experience of the national program will develop to such a level that our network becomes a mutually dependent collaborative research program.

19798

Germplasm Collection, Multiplication and Distribution

Status of the Phaseolus Collection

Five years after the establishment of the Genetic Resources Unit, the world beans Phaseolus collection is comprised of a total of 32,532 accessions, from 47 countries (Table 1). Part of this germplasm resulted from collection expeditions funded by CIAT and IBPGR since 1978 to Mexico, Iberian Peninsula, Peru, Brazil and several African countries. Collections have been reinforced with the appointment of an IBPGR germplasm officer in CIAT in charge of Latin America.

The recent taxonomy of the genus Phaseolus includes four cultivated species and 35 wild or non-cultivated species. CIAT's collection includes the four cultivated species and their corresponding wild ancestors and 10 wild non-cultivated species. Among the cultivated species the common bean Phaseolus vulgaris represents 88.7% of the collection, while the other cultivated species Phaseolus lunatus, Phaseolus coccineus, and Phaseolus acutifolius add up to 11.0% of the collection; the non-cultivated or wild species form only 0.3% of this germplasm collection.

The germplasm bank contains bean legume accessions of other genera, mainly Vigna. They add up to a total of 429 accessions (Table 1).

Sources and origin of the germplasm

A study on the source and/or the real or previous origin of the germplasm accessions was initiated with the aid of the new computer facilities. The accessions will be grouped by common geographical area of origin to enable detection of duplicate or similar germplasm.

The Phaseolus vulgaris or common bean collection

The source of the accessions of this species is very diverse, in fact, 47 countries representing the five continents have sent either their entire or part of the national collections to CIAT for preservation. When the source and the real or previous origin of the germplasm is compared (Table 2), a noticeable difference is observed between the importance of the source versus the origin of the accessions. Thus, North America representing 33% of the source and Europe (22%), are the major donors of common bean germplasm. However, by tracing the donor's previous source or the real origin of the materials, Central America appears to be the most important contributor (31% collection), followed by South America (17%). These results are in agreement with the theory the origin of beans is in America. On the other hand, it may also suggest a tremendous germplasm exchange of this species and consequently the likelihood of germplasm duplication.

It also clearly demonstrates the lack of information of a high percentage of the germplasm (18) on their previous origin. This

Table 1. Status of the *Phaseolus* bean collection held at CIAT (as of October 1982).

Cultivated species	No. of accessions	%
P. vulgaris	28,542	
P. vulgaris ancestral form	332	88.7
P. lunatus	2,282	
P. lunatus ancestral form	62	7.2
P. coccineus subsp. *coccineus*	710	
P. coccineus subsp. *polyanthus*	314	3.3
P. coccineus ancestral forms	58	
P. acutifolius	89	
P. acutifolius ancestral form	59	0.5
Non-cultivated species		
P. anisotrichus, *P. filiformis*, *P. galactoides*, *P. microcarpus*, *P. metcalfei*, *P. pedicellatus*, *P. polystachius*, *P. parvulus*, *P ritensis*, *P. wrightii*	84	0.3
Total	32,532	100.0
Other genera		
Vigna, *Psophocarpus*, *Macroptilium*, others	429	

Table 2. Comparison of the source vs. the origin of the germplasm of *P. vulgaris*.

Region	Source Accessions (no.)	Source (%)	Origin[a] Accessions (no.)	Origin[a] (%)
North America	9,568	33.1	1,104	3.8
Central America	5,217	18.1	9,020	31.2
Caribbean	84	0.3	77	0.2
South America (Andean)	3,692	12.8	3,899	13.5
South America (non-Andean)	1,361	4.7	1.413	4.9
Europe	6,463	22.4	3,436	11.9
Africa	2,065	7.1	1,657	5.7
Middle East	-	-	2,016	7.0
Asia-Oceania	424	1.5	1,067	3.7
Unknown	-	-	5,185	18.0
Total	28,874	100.0	28,874	100.0

a. Refers to previous donor source.

situation combined with the still insufficient data of the remainder, makes it very difficult to detect duplications. Nevertheless more information is being sought for agronomic and seed type characterization. In this germplasm introduction, clusters will be formed which have a high percentage of similarity. These "packages" of similar germplasm will be useful information especially to breeders. It will also facilitate the management of the collection.

Other cultivated species of *Phaseolus*

The situation for the other cultivated species of *Phaseolus* is similar to that of the common bean. While North America (33%) and Europe (21%) are the major donors of the germplasm of these species (Table 3), Central America (37%) and South America (22%) appear as the most important sources of this germplasm. Likewise, for a high percentage of the germplasm CIAT's donors had no information on the previous source (28%). The lack of sufficient information is the main problem facing germplasm introduction.

Seed Increase

Due to the size of the collection and the needs of the Bean Team, major emphasis is placed on the increase of new germplasm. However, due to the very small seed samples available, seed quality problems and legal requirements of the received germplasm, a methodology to increase new germplasm has been established in agreement with ICA. This methodology consists of three consecutive steps:

Quarantine

The Instituto Colombiano Agropecuario (ICA) classifies the accessions according to the pest-disease risk of the country source. It decides which germplasm can be increased directly in CIAT's greenhouse and which must be increased in ICA's quarantine facilities. The last release of 5000 accessions which could be grown in CIAT's greenhouse was authorized in late 1981.

CIAT's greenhouse

The germplasm released by ICA is grown in the greenhouse at CIAT. Most of the introduced materials are of old seed with poor vigor and need to be pregerminated. This is done by scarification by a cut in the seedcoat and a desinfection with sodium hipochlorite (8%). Seeds are then placed in petri dishes in an incubator under controlled temperature, light and humidity. Those seeds which succeed in germinating are transplanted to pots in the greenhouse, where a phytosanitary follow-up and preliminary data on characterization are carried out. The percentage of success in the pregermination varies greatly according to the seed source, but losses range between 10-60%. This process is laborsome and slow, and when combined with the limited greenhouse space available, allows to process only 700 accessions per planting with a range of 50-100 seeds per accession.

Table 3. Comparison of the source vs. the origin of the germplasm of *P. lunatus*, *P. coccineus*, and *P. acutifolius*.

Region	Source (%)	Origin (%)
North America	35.6	4.3
Central America	18.6	36.2
Caribbean	0.4	0.9
South America (Andean)	4.7	9.0
South America (non Andean)	2.7	12.6
Europe	11.5	2.6
Africa	26.2	4.1
Middle East	-	0.5
Asia-Oceania	0.3	1.3
Unknown	-	28.5
Total	100.0	100.0

Isolated field

The seed produced in the greenhouse is further multiplied in an isolated field in a dry xerophytic area in Dagua (26°C and 500 masl). The incidence of bacterial and fungal diseases is very low here. Three meter rows per accession are planted which produces in general more than 100 grams of seed. Preliminary morphoagronomic data are collected as well.

Germplasm Evaluation

The objective of the evaluation is to "characterize" or individualize the germplasm accessions. To evaluate the germplasm of *Phaseolus vulgaris* 27 "minimum" morphoagronomic characteristics are used. The evaluation of the other cultivated species had not started. However, an evaluation for pest and disease resistance has been carried out for *P. coccineus* and *P. acutifolius*.

Seed description

The most important characteristics used to classify the common bean is the seed type. The classification of the germplasm according to seed types has been initiated. The first part of this study involves color grouping (Figure 1) in which the predominant seed colors of the germplasm accessions of the common bean are white (22.5%), red (21.1%), black (20.2%), and cream (18.0%). The cream-beige group presents the highest percentage of seeds having more than one seedcoat color (58%). In the other color groups less than 35% of the accessions combine more than one color. The black color is least combined with other colors (2.6%).

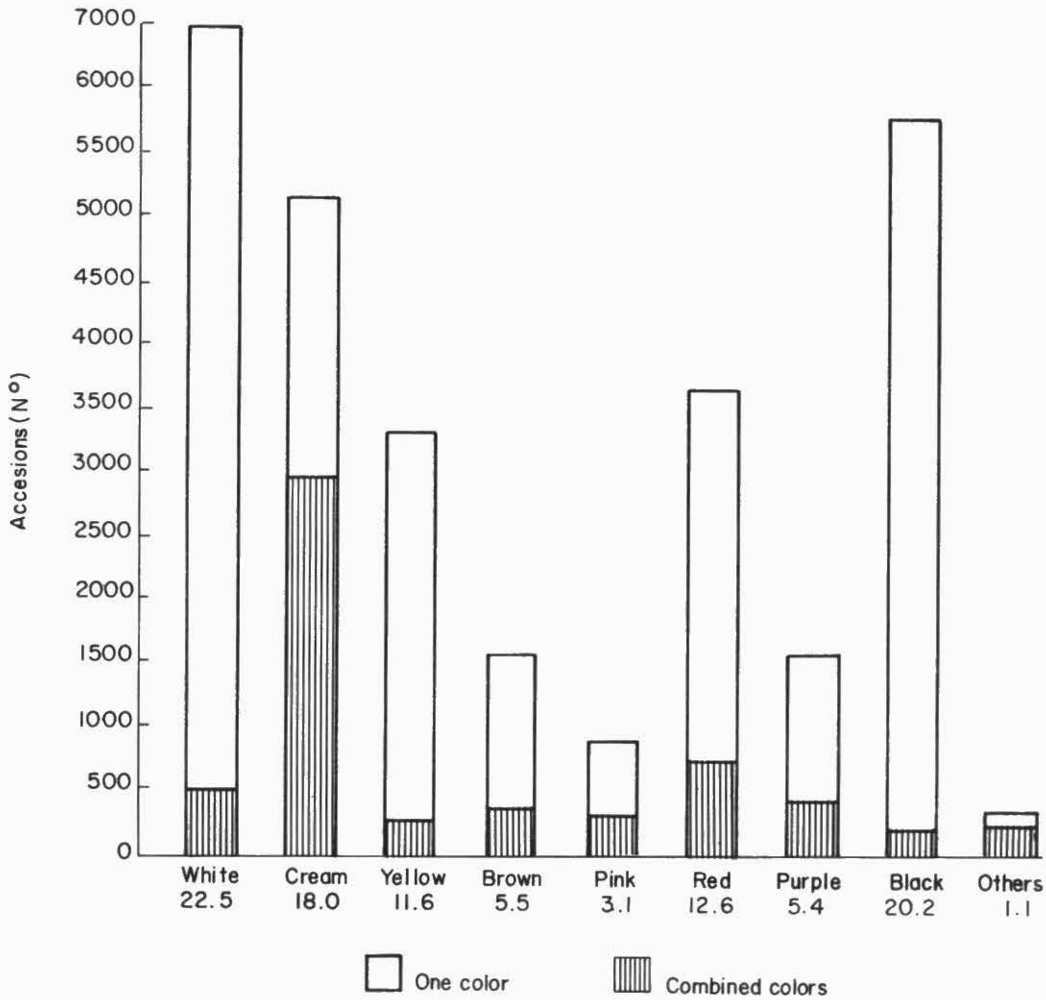

Figure 1. Seed color distribution of the germplasm bank accessions of *P. vulgaris* and the proportion of one vs. combined colors.

Agronomical characteristics

Phaseolus vulgaris. A comparative study of the main agronomical characteristics of each germplasm accession is being carried out. It will be used to establish which characteristics are more reliable as clustering criteria. The results of the first evaluations under Palmira conditions are shown in Table 4, which includes 6 of the most important agronomical characters out of the 27 "minimum" descriptors used for evaluation. These evaluations which include the four growth habits show that duration of flowering (c.v. 30.6%), nodes on the main stem at maturity (c.v. 36.1%) and pods per plant (c.v. 57.5%) are the characters presenting a remarkable variation which indicates that an ample natural variability is available to breeders for selection. On the other hand, seeds per pod (c.v. 22.0%) and days to flowering (c.v. 13.2%) are the characters showing least variation. Taking the least variable character, days to flowering (c.v. 13.2%), as reference point, it is concluded that duration of flowering is 2.3, nodes at flowering is 2.0, nodes at maturity is 2.7, seed per pod is 1.7 and pods per plant is 4.4 times more variable than days to flowering (Table 5).

Table 4. Variability of some morphoagronomic traits used for the evaluation of the P. vulgaris germplasm.[a]

Characteristic	Mean	Standard deviation	C.V. (%)	Sample size
Days to flowering	36.0	4.7	13.2	9,003
Duration of flowering	23.3	7.1	30.6	8,958
Nodes at flowering	12.6	3.4	26.8	8,192
Nodes at maturity	15.3	5.5	36.1	7,772
Pods per plant	17.6	10.1	57.7	9,644
Seeds per pod	4.9	1.1	22.0	8,727

a. Includes all four growth habits evaluated in CIAT-Palmira.

Table 5. Variability factor[a] of six morphoagronomic traits in Phaseolus vulgaris.

Characteristic	V.F
Duration of flowering	2.3
Nodes to flowering	2.0
Nodes to maturity	2.7
Pods per plant	4.4
Seeds per pod	1.7

a. $\text{V.F.} = \frac{\text{c.v. of any characteristic}}{\text{c.v. of least variable character (days to flowering)}}$

Other cultivated species of Phaseolus

A preliminary seed description on the other cultivated species shows that the variation in colors is similar to that of the common bean (Table 6). However, white, cream-beige, and red are the predominant colors for P. lunatus, while white is the predominant seedcoat color of P. acutifolius. This latter species does not have red seeded types. P. coccineus, being cross pollinated species, shows that individual accessions have different colors; only the predominant color is recorded.

Table 6. Color distribution of the germplasm accessions of *P. lunatus*, *P. coccineus*, and *P. acutifolius*.

	Species		
Seed color	*P. lunatus*[a] (%)	*P. coccineus*[a] (%)	*P. acutifolius*[a] (%)
White	43.7	12.2	50.3
Cream-beige	13.0	14.9	6.5
Yellow	2.0	10.4	5.9
Brown-maroon	1.0	1.5	7.8
Pink	2.7	8.1	-
Red	15.4	18.9	-
Purple	3.9	7.2	0.6
Black	14.8	20.0	7.8
Others	3.4	6.8	20.9
Total	100.0	100.0	100.0

a. Percentage of the available germplasm.

Evaluation of wild types of the common bean and other cultivated species for interspecific hybridization (University Gembloux)

The CIAT-Gembloux project aims to increase the variability of the common bean through interspecific hybridization with its wild relatives and other species of the genus specially *P. coccineus*. The seed increase and evaluation of wild *P. vulgaris* has been finished and the main conclusions are summarized. To date the CIAT collection includes 337 wild *P. vulgaris* accessions. The results of the agronomical and morphological evaluations indicate that most of the wild forms are not interesting sources for plant architectural characters to improve the common bean.

The results of the evaluation for disease and pest resistance indicate that the wild *P. vulgaris* forms are especially interesting as sources for stored grain insect resistance. Some accessions present a very outstanding level of resistance never found in the cultivated form (Table 7).

The origin of the common bean has been a much debated question for many years. Two hypotheses have been presented by different authors, either than Mexico or South America are a single center of origin or that those two locations are two independent centers of domestication. The low number of South American wild forms in the CIAT germplasm does not allow to confirm these hypotheses. More collections of wild *P. vulgaris* from Mexico to Argentina will permit a study on the relationship between the Mexican and the South American wild forms.

Table 7. Evaluation of disease and pest resistance of the wild P. vulgaris.

Disease or pest	No. of accessions evaluated	Number of accessions reported as: Susceptible	Intermediate	Resistant
Bean golden mosaic virus	136	134	2	0
Common bacterial blight (Xanthomonas phaseoli)	249	235	14	0
Asochyta leaf spot	276	246	30	0
Leafhopper (Empoasca kraemeri)	235	235	0	0
Zabrotes subfasciatus	234	193	32	9
Acanthoscelides obtectus	227	23	58	146

A preliminary study of variability in wild forms was carried out to find discriminant characters to eliminate duplicates and to separate the different wild forms. The most discriminant characters are: white variegation along the primary leaf vein, the bracteole size and shape, the number of veins per bracteole, the seed color and pattern, the peduncle length and the number of floral insertions on the raceme, the number of seeds per pod and the 100 seed weight.

The method to increase cross pollinated P. coccineus, as reported last year, is by using meshcages with 13 plants per cage and manual pollination. During 1981-82, 150 accessions were planted at Popayan and 48 accessions were seed increased according to that methodology. During the seed increase, agronomical and morphological characters were observed. The preliminary results show high morphoagronomic variability intra and inter accessions. A list of 39 descriptors for evaluation was proposed as a result of this evaluation.

Germplasm Storage

One of the prevailing responsibilities of the Genetic Resources Unit is the germplasm preservation. To meet this objective, two types of storage have been established: long- and short-term.

Short-term is the active or "working" collection whose storage conditions are: 5-8°C temperature, 12-15% seed moisture content, 60-65% relative humidity, and packed in plastic jars (800 g). To date there are about 17,000 accessions (mostly of P. vulgaris) which have filled the capacity of the cold room. This situation implies a future gradual change of containers or a shelf re-arrangement of the cold room.

Long-term storage to preserve the collection has been set up under the following conditions: -2° to -6°C temperature, 5-8% seed moisture content, 60-65% relative humidity and packed in sealed laminated soil bags. To date there are more than 2500 accessions of *P. vulgaris* stored under these conditions. However, equipment problems as well as cold room isolation difficulties have prevented storing germplasm at a faster rate.

Seed and/or Information Distribution

The foremost responsibility of germplasm management is to make it available to institutions and scientists. This task has been achieved since the creation of the GRU. Over the last five years 66, 668 samples have been distributed. Of this total, 21,707 samples have been sent to institutions and scientists of national programs (Table 8), and 45,067 samples to the CIAT Bean Team (Table 9).

Table 8. Germplasm seed service to national institutions and scientists outside CIAT, during 1977-82.

Region	Total requests	Total accessions
North America	32	562
Central America	36	14,318
Caribbean	8	1,048
South America (Andean)	54	1,488
South America (non-Andean)	37	1,091
Europe	51	1,125
Africa	17	1,473
Asia-Oceania	27	682
Total	262	21,787

Table 9. Germplasm distribution to CIAT Bean Team during 1977-82.

Disciplines	Total requests	Total accessions
Breeding	101	24,543
Entomology	79	12,080
Phytopathology	47	2,916
Physiology	11	747
Agronomy	43	3,508
Microbiology	12	1,034
Tropical Pastures	5	17
Special Studies	4	53
Cultural Practices	3	155
Cassava	2	4
Seed Unit	2	10
Total	309	45,067

Germplasm Screening and Genetic Improvement

Introduction

Germplasm improvement activities of the Bean Program are based upon the large variability in the germplasm collection stored at CIAT. Useful traits are identified in the evaluation of the germplasm bank with the potential to solve or reduce the effect of production limiting factors. However, in many instances the level of expression of desirable traits is insufficient in bank accessions to solve the particular production constraints; e.g., the level of resistance to bean golden mosaic virus, ascochyta leaf spot, drought, storage insects, ability to fix atmospheric nitrogen, etc. For the improvement of commercial varieties several of these factors need to be combined. Genetic improvement activities of the Bean Program can therefore be divided into two aspects: a) Character improvement. This is the development of maximal expression of a character in a diversity of genotypes by accumulating different genes, mechanisms, etc., and b) Cultivar improvement. The recombination or use of these characters into commercial cultivars according to the needs of the particular production region the material is intended for forms the second improvement activity.

This section of the report is written according to these two improvement activities: character improvement and cultivar improvement. Table 1 lists the specific responsibilities of the three breeders in these activities, and the numbers of crosses made during 1982.

Table 1. Responsibilities for character and national cultivar improvement of the three breeders of the Bean Program.

Research area	Responsible breeding program		
Character improvement			
Bean common mosaic virus	I[a]		
Bean golden mosaic virus	I		
Rust	I		
Common bacterial blight	I		
Halo blight			III
Web blight	I		
Anthracnose		II	
Angular leaf spot		II	
Ascochyta leaf spot			III
Mildew			III
Bean scab			III
Empoasca leafhoppers	I		
Apion pod weevil	I		
Bruchids			III
Beanfly			III
Mexican bean beetle		II	
Nematodes			III
Drought		II	
Low temperature			III
Low P		II	
Early maturity		II	
N_2 fixation	I		
Architecture		II	
Snap beans			III
National cultivar improvement			
Central America, Caribbean, Coastal Mexico, Peru, Chile, and black beans	I		
Mexican highlands, Brazil, Argentina		II	
Andean zone, Africa			III

a. Breeding program I: S. Temple
II: S. Singh
III: J. Davis

19799

Resistance to Fungal and Bacterial Diseases

The major activity of the Bean Pathology section is the screening of bean germplasm for their disease resistance in nurseries that are methodically exposed to one or more pathogens in several locations and environments where these bean pathogens may occur naturally. Similarly, a major effort of the program is towards the development and evaluations of disease resistance mechanisms with the purpose of finding resistance that is effective against the many organisms that attack beans, several of which possess wide pathogenic variation.

The Bean Pathology section does evaluate on a routine basis germplasm bank accessions and hybrid progenies from specific breeding projects for specific pathogens in the field and in the greenhouse. Some of the specific nurseries, such as the International Bean Rust Nursery, are repeatedly evaluated in many areas of the world where the disease is endemic. Advance uniform nurseries such as the Bean Team Nursery, VEF and the Preliminary Yield Trial EP, are also evaluated for their reaction to several pathogens in various locations (Table 1). The emphasis continues to be the identification and selection of resistant germplasm to anthracnose, rust, common bacterial blight, angular leaf spot and web blight. These are the most important and widespread diseases of beans in the Americas. Bank accessions and some advanced progeny from uniform nurseries are also evaluated for their resistance to other important but to less widespread diseases such as ascochyta leaf spot, halo blight and roots rots.

Rust. Bean rust caused by *Uromyces phaseoli* is one of the most widespread and complex bean pathogens with respect to pathogenic variation as demonstrated by several years of data collected through the International Bean Rust Nursery (IBRN), a CIAT nursery that is evaluated in many locations throughout the world. The evaluations of the IBRN

Table 1. Number and proportion of bush and climbing bean entries of the 1982 EP nursery according to their reaction in the field to diseases in Palmira and Popayan, Colombia[a].

Rating[b]	Rust	Common bacterial blight	Anthracnose	Angular leaf spot	Ascochyta leaf spot
Resistant	98 (32.2%)	12 (3.9%)	169 (55.6%)	111 (36.5%)	22 (7.2%)
Intermediate	88 (28.9%)	32 (10.5%)	56 (18.4%)	52 (17.1%)	152 (50.0%)
Susceptible	117 (38.4%)	257 (84.5%)	47 (15.5%)	110 (36.2%)	91 (29.9%)

a. Rust and common bacterial blight evaluated at CIAT-Palmira and anthracnose, angular leaf spot and ascochyta leaf spot at Popayan.

b. Rating based on a 1-5 scale where 1 is immune and 5 is highly susceptible; 1 and 2 = resistant; 3 = intermediate; 4 and 5 = susceptible.

from 1975 to 1982 show that many of the cultivars tested are resistant only on specific locations, strongly suggesting race-specific resistance. In addition, some bean cultivars that were resistant in a given location for one or more years, were evaluated as susceptible later on. One case in point is the cultivar Compuesto Chimaltenango 2 (G 5711) which had a resistant or intermediate reaction in Colombia from 1975 to 1980; however, it was severely attacked by rust at CIAT-Palmira during the second semester in 1981. Similarly, released bean lines that when initially evaluated as resistant in a given location, for example the bean line Talamanca evaluated in Costa Rica, later on had a considerable rust attack in that location.

On the other hand, it has been possible to identify from the IBRN a number of bean varieties as well as CIAT developed lines that appear to have stable and possibly non-race specific resistance. Tables 2 and 3 show these widely resistant bean varieties and CIAT lines that show resistance stability over a very wide range of locations during several years of evaluations. From the 1981-1982 IBRN a number of new CIAT lines with resistance to the rust pathogen in many locations had been also identified (Table 4).

Race-specific resistance in bean to rust is available in a wide range of genotypes . However, due to the ample pathogenic variation of the rust fungus, the objective of the Bean Program is to identify new and/or non-race specific rust resistance mechanisms that will be stable or durable. We also continue our investigations, as reported last year, on the influence and importance of some components of rate-reducing or stable rust resistance such as, rust pustule size, latent period, rust incidence and severity, disease progress through time, and the influence of these components on yields, with the purpose of identifying criteria that will aid in the search for cultivars with the type of durable resistance.

Table 2. Rust reaction of widely resistant selected bean cultivars from the International Bean Rust Nursery (IBRN), evaluated in several countries from 1977 to 1982.

Bean cultivar	IBRN 1975-76[a]				IBRN 1977-78[a]				IBRN 1979-80[a]				IBRN 1981-82[a]			
	IM[b]	R	IT	S	IM	R	IT	S	IM	R	IT	S	IM	R	IT	S
Redlands Pioneer	2	7	5	2	3	11	2	0	3	11	7	1	1	5	2	0
Redlands Greenleaf B	9	11	7	2	3	11	2	0	4	8	9	1	1	6	1	0
Redlands Greenleaf C	2	9	8	2	8	4	4	0	2	12	8	0	2	4	2	0
Cuilapa 72	12	10	4	3	7	7	3	0	5	7	9	1	1	3	3	1
Cocacho	5	9	2	3	2	7	8	0	3	7	10	1	1	5	2	1
Mexico 309	14	9	4	2	8	7	1	1	8	10	3	1	1	3	2	2
Mexico 235	8	5	6	2	5	6	2	2	4	14	4	0	1	1	4	2
Pinto 650 (susceptible check)	0	1	3	28	0	1	3	11	0	2	0	20	0	0	0	7

a. IBRN evaluations; 1975-1976: 11 countries, 30 locations; 1977-1978: 11 countries, 17 locations; 1979-1980: 10 countries, 22 locations; 1981-1982: 5 countries, 8 locations.
b. IM = immune; R = resistant; IT = intermediate; S = susceptible.

Table 3. Rust reaction of selected widely resistant CIAT bean lines from the International Bean Rust Nursery (IBRN), evaluated in several countries from 1979 to 1982.

Entry	Grain color	IBRN 1979-1980[a]				IBRN 1981-1982[a]			
		IM[b]	R	IT	S	IN	R	IT	S
EMP 9	Black	6	8	6	2	0	2	5	1
BAT 48	Black	1	5	6	2	1	3	4	0
BAT 73	Black	4	9	7	2	1	4	3	0
BAT 256	Brown	4	12	4	2	1	5	0	2
BAT 93	Cream	4	10	7	1	2	3	3	0
BAT 308	Black	5	9	7	1	1	3	3	1
BAT 429	Black	4	8	9	1	1	2	2	2
BAT 447	Black	5	7	9	1	2	3	2	1
BAT 520	Black	6	10	5	1	2	3	3	0
BAT 66	Black	5	9	8	0	1	3	3	1
BAT 76	Black	4	13	5	0	1	5	2	0
BAT 261	Black	7	8	7	0	2	2	3	1
V 3249	Black	6	13	3	0	1	5	1	1
Pinto 650 (susceptible check)	Cream mottle	0	2	0	20	0	0	0	7

a. IBRN evaluations; 1979-1980: 10 countries, 22 sites; 1981-1982: 5 countries; 8 locations.
b. IM = immune; R = resistant; IT = intermediate; S = susceptible.

Table 4. Rust reaction of selected CIAT bean lines from the 1981-1982 International Bean Rust Nursery evaluated in five countries and eight locations.

Entry	Grain color	Rust reaction[a]			
		IM	R	IT	S
Pinto 650 (susceptible check)	Cream mottle	0	0	0	8
BAT 260	Black	1	3	4	0
BAT 336	Cream	2	2	4	0
BAT 338	Black	2	3	3	0
BAT 448	Black	1	4	3	0
BAT 1210	Cream	3	2	3	0
BAT 1211	Cream	1	4	3	0
BAC 41	Black	1	4	3	0
A 62	Brown	3	4	1	0
A 63	Cream	2	4	2	0
A 155	Cream	1	5	3	0
A 161	Cream	1	1	6	0
A 167	Cream	2	3	3	0
G 1089	Cream	3	4	1	0
BAT 41	Red	3	2	1	2

a. IM = immune; R = resistant; IT = intermediate; S = susceptible.
IBRN evaluations: United States (3); South Africa (1), Colombia (2), Brazil (1), Guatemala (1).

In the breeding for rust resistance in beans, efforts continue to emphasize the identification of new sources of resistance and the incorporation of rust resistance from several sources into the new lines. In addition, a number of bean cultivars that are potential parents to black and red-seeded materials for Central America that are relative uniform for grain type, plant growth habit and maturity are being evaluated for their rust reaction in that area. These materials will be utilized in a project that involves the production of early generation composite varieties for Central America with the expectation of having durable resistance.

Common Bacterial Blight (CBB). In the evaluation of resistance to CBB, the procedures utilized (CIAT, Annual Report 1979 and 1981) continue to emphasize the foliar reaction without neglecting the pod reaction. During 1982, the foliar and pod reaction of 58 bean lines to the CBB pathogen was studied. Leaves and pods were inoculated with the colombian isolate xp 123 using the razor blade procedure for the leaf inoculation and a hypodermic syringe needle for pod inoculation. Leaves were evaluated using a disease severity scale of 1-5. The pod lesion diameter (PLD) was measured and converted to a severity index (PSI). The correlation between the foliage reaction and the PLD and PSI was of 0.8352 and 0.8043 respectively, suggesting that bean plants selected for foliage resistance to the CBB pathogen are very likely to also have resistant pods.

Emphasis in the development of resistance to Xanthomonas phaseoli (X. campestris pv. phaseoli) the CBB pathogen, during 1980 and 1981 resulted in a increased number of resistant lines with different grain types (Table 5). Ten new lines with CBB resistance were coded in 1982, the majority of which were the result of purifying families made in early crosses.

Table 5. Disease reaction of selected 1982 EP bean lines to the common bacterial blight pathogen evaluated in the field at CIAT-Palmira.

		Disease reaction	
Identification	Color	EP 82	VEF 81
BAC 87	Black	2.5	2.5
BAC 112	Black	2.0	2.5
BAT 1336	Red	3.0	3.0
BAT 1449	Red	3.0	3.0
BAT 1501	Red	2.5	2.5
BAT 1514	Red	2.0	3.0
BAT 1631	Red	3.0	3.0
BAC 125	White	2.0	3.0
A 493	White	2.0	3.0
BAC 105	Cream	2.5	3.0

Disease reaction: 1 = immune; 2 = resistant; 3 = intermediate; 4 susceptible; 5 = very susceptible.

For the 101 new crosses made for CBB resistance during 1982, two approaches are being pursued for the increasing of CBB resistance levels: (1) by means of intraspecific crosses and (2) by backcrossing interspecific progenies carrying the CBB resistance of P. acutifolius to tropically adapted P. vulgaris breeding lines. Resistant interspecific donors of the latter were provided by the University of California at Riverside.

The results of the evaluations of 13 CBB resistant selections at several U.S. Universities where active CBB work is being conducted are promising. Similarly, in an effort to determine the necessary levels of CBB resistance in different grain types for different bean growing regions, 18 CIAT bean lines and national program cultivars possessing different levels of CBB resistance are being evaluated at CIAT-Palmira and by a national program in Central America. The yield and the CBB reaction of these cultivars are evaluated under protected, natural and high CBB disease pressure conditions. Some of these lines combine CBB resistance with earliness and high yield potential. Efforts are being made to recombine some of these characters and adaptation into a broad range of commercial grain types. Lines possessing CBB resistance are used as parents in crosses for resistance to web blight, bean golden mosaic and Empoasca.

Antracnose and angular leaf spot. These two diseases often occur together in bean growing regions with moderate to cool temperature and abundant moisture. Both, Colletotrichum lindemuthianum, the causal agent of anthracnose and Isariopsis griseola, the angular leaf spot (ALS) fungus are pathogenically variable, and a bean variety that is resistant to either one of these pathogens in one area, may not be in a different region. In 1982 conducting an evaluation of bean accessions from the germplasm bank, CIAT advanced lines and segregating progeny, in the highlands of México, it was observed that some of the lines resistant to anthracnose in Colombia, were not resistant in México. The bean cultivar Amapola del Camino, as well as the CIAT bean lines BAT 44 and BAT 841 previously known for their resistance in the field and greenhouse to all European and Latin American isolates of Colletotrichum lindemuthianum, were susceptible in México. The cultivars Bayomex and Perry Marrow on the other hand, had no anthracnose symptoms in México; however, they are highly susceptible in Popayán, Colombia. These results as shown in Table 6 demonstrate that the populations of the anthracnose pathogen in the highlands of México and Colombia are pathogenically different. Many of the CIAT bean lines and other bean varieties however had the same reaction to the disease in both locations. Table 7 shows the reaction of selected bean cultivars, with resistance to anthracnose in both locations.

The pathogenic situation of the ASL fungus is similar to that of the anthracnose pathogen. Table 8 shows a number of CIAT bean lines that were evaluated as either resistant or susceptible in Brazil and Colombia as well as some that had different reactions in both locations. Again, many lines were found to have resistance to ALS in both countries as shown in Table 9.

Table 6. Differential reaction in the field of selected bean cultivars to *C. lindemuthianum* in Popayan, Colombia and Tepatitlán, Mexico.

Identification	Anthracnose reaction[a] Colombia	Mexico
BAT 44	R	S[b]
BAT 841	R	S
A 279	R	R
A 262	R	R
Perry Marro	S	R
Bayomex	S	R
BAT 76	S	S
BAT 41	S	S

a. R = resistant; S = susceptible. Disease rating base in 1-5 scale; 1 = no symptoms, 5 = very severe symptoms; 1 and 2 = resistant; 4 and 5 = susceptible.
b. R = resistant; S = susceptible.

Table 7. Anthracnose reaction of bean cultivars under field conditions in Tepatitlán, Mexico, and Popayan, Colombia.

Identification	Grain color	Anthracnose reaction[a] Mexico	Colombia	Identification	Grain color	Anthracnose reaction Mexico	Colombia
A 149	Bayo	R	S	A 440	Ojo de Cabra	R	R
A 174	Pinto	R	I	A 441	Ojo de Cabra	R	R
A 177	Bayo	R	R	A 443	Ojo de Cabra	R	R
A 196	Bayo	R	I	A 444	Ojo de Cabra	R	R
Amapola del Camino		S	R	A 445	Ojo de Cabra	R	R
Toche 400		S	I/R	Quarenteño		R	R
A 406	Flor de Mayo	I	I	Mexico 222	Bayo	R	R
A 401	Flor de Mayo	R	R	G 1038		R	R
A 408	Flor de Mayo	R	R	G 1042		R	R
A 410	Bayo	R	R	G 2641	Pinto	R	R
A 411	Bayo	R	R	G 2646	Pinto	R	R
A 423	Pinto	R	R	G 2874		I	R
A 424	Pinto	R	R	G 5653		R	R
A 439	Ojo de Cabra	R	R	G 11960		R	R

a. Anthracnose reaction based on 1-5 scale; where 1 (no symptoms) and 2 (very little disease) are considered resistant; 3 = intermediate and 4 and 5 (very severe symptoms) are considered susceptible.

Table 8. Differential reaction in the field of selected bean cultivars to *Isariopsis griseola* in Colombia and Brazil.

Identification	Disease reaction[a] Popayan Colombia	Anápolis Brazil
A 140	R	R
A 154	R	R
A 160	R	S
A 210	R	S
A 96	S	S
A 161	S	S
A 339	S	R
A 340	S	R

a. Disease rating base in 1-5 scale: 1 = no symptoms; 5 = very severe symptoms; 1 and 2 = resistant; 4 and 5 = susceptible.

Table 9. Reaction of selected bean cultivars with resistance in the field to angular leaf spot in Brazil and Colombia during 1982.

Entry	Brazil		Colombia
	Caruarú	Anápolis	Popayan
A 140	I	I	R
A 299	I	I	R
A 153	I	I	I
A 154	I	R	R
A 337	I	R	I[a]
A 338	I	R	I[a]
A 339	I	R	I[a]
A 340	I	R	I[a]
A 75		I	R
A 82		R	I
A 214		I	R[a]
A 216		I	R
A 217		I	R
A 218		I	I
A 219		I	R

(Continued)

Table 9. (Continued)

A 235	I	I[a]
A 237	I	R
A 286	R	I
A 295	R	R[a,b]
A 296	R	I[a,b]
A 298	R	R
A 332	I	I
A 337	R	I[a,b]
A 338	R	I[a]
A 339	R	I[a,b]
A 340	R	I[a,b]
A 345	R	R
A 384	R	I[a]

a. Had also either resistant or intermediate anthracnose reaction in the field, Popayan, 1981B.

b. Had also either resistant or intermediate anthracnose reaction in the greenhouse to: 1) an isolate of C. lindemuthianum from Capivara, Brazil; 2) to the race Alpha Brazil; and 3) a mixture of both isolates.

In breeding for resistance to anthracnose and ALS of beans, the search for new and or different sources of resistance to these diseases continues to be emphasized; however, the balance at present is in favor of anthracnose. Generally, anthracnose is more widespread and it is under field conditions easier to create epyphytotics of anthracnose when natural conditions do not favor a build up of the disease. The situation is the same in the greenhouse. In the last few semesters, field epyphytotics with both diseases have allowed reliable evaluations of parental material, segregating progenies and advanced lines. From the evaluations conducted in Popayan of the 1981 VEF and subsequently of the 1982 EP a number of materials possessing different grain color and commercial acceptance, were identified as having very good levels of resistance to both, anthracnose and angular leaf spot (Table 10).

Many of the lines from the 1981 VEF evaluated as resistant in the field in Popayan, having Brazilian grain types, were also evaluated separately in the greenhouse for their resistance to an isolate of C. lindemuthianum from Capivara, Brazil, to the race Alpha Brazil and also evaluated with a mixture of both populations. Table 11 shows the anthracnose and ALS reaction of these materials in Popayán, as well as their reaction in the greenhouse and the ALS reaction in Anapolis, Goiania, Brazil. Most lines, had excellent levels of anthracnose resistance in the field and greenhouse. Some lines had in addition to anthracnose resistance, intermediate or resistant ALS reaction either in Colombia or Brazil; however most were ALS susceptible.

Table 10. Anthracnose and angular leaf spot reaction of selected bean lines with resistance under field conditions to both pathogens in Popayan, Colombia.

		VEF 1981		EP 82	
Identification	Grain color	ANT	ALS	ANT	ALS
BAT 1449	Red	1.5	1.0	1.5	2.0
BAT 1629	Red	2.0	2.0	1.5	2.0
A 475	Purple mottle	2.0	2.5	1.0	1.0
A 476	Purple mottle	1.5	1.0	1.5	1.5
A 485	Purple mottle	1.5	1.0	-	1.0
BAT 1386	Purple mottle	2.0	1.0	1.0	1.0
BAT 1426	Pink striped	1.0	1.0	1.0	1.5
BAT 1620	Puprle mottle	1.5	2.0	1.5	1.5
A 492	White	2.0	2.5	2.0	2.0
BAT 1542	Canario	1.5	2.0	1.0	2.0
A 242	Pink stiped	2.0	1.0	2.0	2.5
A 271	Bayo striped	1.5	2.5	1.0	2.0
A 296	Bayo or cream	1.0	2.0	1.0	1.0
A 348	Bayo or cream	1.0	2.0	1.5	2.0
A 395	Bayo or cream	1.5	2.5	1.5	1.5

Disease reaction based on a 1-5 scale: 1 = immune; 5 = very susceptible.

Table 11. Reaction of anthracnose resistance bean cultivars and CIAT bean lines to isolates of C. lindemuthianum from Brazil and their reaction to angular leaf spot.

	Anthracnose reaction[a]				Angular leaf spot reaction[b]	
Identification	I	II	III	IV	I	II
A 242	R	R	R	R	R	R
A 243	R	R	R	R	I	S
A 248	R	R	R	R	I	I
A 249	R	R	R	R	I	I
A 250	R	R	R	R	I	I
A 251	I	I	I	I	R	S
A 252	R	R	R	R	S	I
A 253	R	R	R	R	S	I
A 254	R	R	R	R	S	I
A 255	R	R	R	R	S	S
A 256	R	R	R	R	S	I
A 257	R	R	R	R	S	S
A 258	R	I	I	I	S	S

(Continued)

Table 11. (Continued)

A 259	R	R	R	R	S	S
A 262	R	R	R	R	S	I
A 263	R	R	R	R	S	S
A 264	R	R	R	R	S	S
A 294	R	R	I	R	I	R
A 295	R	R	I	R	R	R
A 296	R	R	R	R	R	R
A 305	R	R	R	R	S	S
A 317	R	R	R	R	S	I
A 318	R	R	I	R	S	I
A 319	R	R	R	R	S	I
A 320	R	R	R	R	S	R
A 321	R	R	R	R	S	R
A 322	R	R	R	R	I	I
A 323	R	R	R	R	S	R
A 329	R	R	R	R	S	S
A 331	R	R	R	R	S	R
A 337	R	R	I	R	I	R
A 338	R	R	I	R	I	R
A 339	R	R	I	I	I	R
A 340	R	R	I	R	R	R
A 344	R	R	I	R	S	S
A 359	R	R	I	I	I	S
A 364	R	R	I	I	R	S
A 368	R	R	I	R	S	S
A 373	R	R	R	R	I	S
A 374	R	R	R	R	I	S
A 375	R	R	I	R	I	S
A 381	R	R	R	R	S	I
A 387	I	R	I	R	I	I
A 389	R	R	I	I	S	S
A 395	R	R	I	R	R	S
A 399	R	R	I	I	S	S
A 450	R	I	R	R	I	-
EMP 110	R	R	R	R	R	-
EMP 117	I	R	R	R	R	-
BAT 44	R	R	R	R		-
BAT 93	R	R	I	I	R	-
BAT 841	R	R	R	R		-
BAT 1512	S	R	R	R	I	-
BAT 1510	I	R	R	R	I	-
BAT 1550	I/S	R	R	R	S	-
AB 136		R	R	R		-

a. Anthracnose reaction: I = field reaction in Popayan, VEF 1981; II = glasshouse reaction to an isolate of C. lindemuthianum from Capivara; III = glasshouse reaction to the race Alpha Brazil; IV = glasshouse reaction to a mixture of II and III.

b. Angular leaf spot reaction: I = field reaction in Popayan, VEF 1981; II = field reaction in Anápolis, Go., Brazil, 1982A.

The Bean Pathology section routinely evaluates bean germplasm for their resistance to anthracnose and ALS in the field and the in the greenhouse. The best sources of resistance are utilized in a breeding program to incorporate these resistances into commercial varieties according to regions. While evaluating for resistance to anthracnose in the greenhouse, it has been noted that some bean lines such as Ecuador 1056, known to have anthracnose resistance in the field in Popayán and other locations, are susceptible to C. lindemuthianum isolates when inoculated at the seedling stage. Preliminary work to elucidate the nature of this reaction, has been carried out. Plants of Ecuador 1056 of different ages were all inoculated at the same time utilizing the same inoculum source and exposing all plants tothe same environmental conditions. Inoculated one-week old seedlings were very susceptible, but as the age of plants increased the amount of anthracnose symptoms decreased notoriously. Inoculated three-week old plants had very little disease and older plants had no or very minute anthracnose lesions. These preliminary results suggest that field resistance to anthracnose of Ecuador 1056 and susceptibility of its seedlings in the greenhouse may be associated with plant age.

Considering the extensive natural pathogenic variation existing in the population of the C. lindemuthianum attacking beans in the different regions of Latin America, a major effort is dedicated to the combination of different sources of anthracnose resistance in the breeding for broader resistance to this disease. About 25 to 30 bank materials, identified as good anthracnose resistant sources but susceptible to BCMV, are crossed to materials having BCMV resistance in order to transfer BCMV resistance. In this process often 3 or 4 lines are used in the final cross combinations with the objective of obtaining progeny having a very broad anthracnose resistance base in addition to having BCMV resistance.

Work is also underway to study the inheritance of anthracnose and angular leaf spot resistance of selected newly identified sources. The cultivar Top Crop, having resistance to BCMV, but susceptibility to all isolates of C. lindemuthianum is being crossed to a number of resistance sources. There is no knowledge as to how many genes control anthracnose resistance, or if the genes in one source that is resistant to all of the pathogen isolates are the same or different from the genes of another anthracnose resistance source having the same type of resistance.

Web blight. A greater emphasis is being placed in this disease due to its increasing importance in the hot, humid conditions of the lowland tropics of Central America, as well as in some middle altitude regions of South America. In addition to the evaluation for resistance to web blight of the EP nursery and the International Web blight nursery (VIM), in Central America, in cooperation with scientists of the Costa Rican National Program we continue to evaluate F_2 and F_3 populations and to progeny test a large number of single plant selections. Only 12 new crosses were made in 1982 for the web blight resistance project since a large backlog of F_2 and F_4 materials have accumulated. Resistance levels to this disease are intermediate or low and the testing of resistance in the field is often difficult because of the irregular distribution of the inoculum or due to the severity of early infections that result on an excessive amount of disease that overcomes what resistance may be present in the tested germplasm.

During the second semester of 1982 a nursery made of 92 bean cultivars and CIAT lines, some of them know to have intermediate levels of resistance in several locations, were evaluated in cooperation with ICA scientists in the Turipaná, ICA experiment station, where the disease is endemic. Table 12 shows the reaction of some selected CIAT bean lines and other cultivars that had either resistant or intermediate reaction to the disease. The susceptible checks utilized were killed early in the growing cycle. Evaluation of parents, hybrid selections and advanced lines will continue during 1983.

Ascochyta leaf spot. In the cool highlands of Colombia and Guatemala, ascochyta leaf spot is an important disease. It is also reported as important in the Andean zone and Europe. A preliminary study was conducted to test varieties for their resistance to the disease and to evaluate the differences in the reaction to ascochyta leaf spot of bush and climbing beans. A nursery containing 62 varieties

Table 12. Web blight disease reaction of several CIAT lines and other bean cultivars with resistance to the disease in Montería, Colombia, 1982B.

Identification	Disease reaction[a]	Identification	Disease reaction
BAT 1636	1.5	Mexico 12-1	2.5
BAT 1544	1.5	Telaraña 46	3.0 +
BAT 1238	2.0	P.I. 308909	3.0
BAT 1198	2.0 +	BAT 1230	3.0 +°
A 89	2.0 +	BAT 1234	3.0
A 99	2.0 +	BAT 1254	3.0
Jamapa (Venezuela)	2.5 *	BAT 1296	3.0
Telaraña 33	2.5 +	BAT 1297	3.0
S-630-B-C-63	2.5 +	BAT 1434	3.0
Porrillo 70	2.5 *	BAC 33	3.0
BAT 67	2.5	A 86	3.0
BAT 450	2.5	A 113	3.0
BAT 527	2.5	A 148	3.0
BAT 1198	2.5	BAT 1432	3.0
BAT 1203	2.5	BAT 1235	3.5 +°

a. Disease reaction based on 1-5 scale: 1 = highly resistant; 5 = highly susceptible; + = resistant in Costa Rica; * = previously resistant in Monteria, Colombia; ° = resistant in coffee zone, Colombia.

listed as bush beans and 51 varieties as climbers were evaluated in Popayan during the first semester of 1982 in the Gembloux-CIAT collaborative program of interspecific hybridization. Each of these accessions had been previously evaluated as moderately susceptible, moderately resistant or resistant in reports from Guatemala, ICA Colombia and the CIAT EP 1981 and IBYAN 1982. Plants were inoculated a month after planting with a spore suspension containing 1.2×10^6 spores/ml. Agronomic practices for bush and climbing beans were followed. Following the inoculation, daytime and nighttime temperatures reached 29° C and 18° C respectively, conditions which are known to discourage the disease. Two disease evaluations were made, at 7 weeks and 11 weeks after planting, and varieties were classified as resistant, intermediate or susceptible (Figure 1). Nine bush bean lines were selected as having intermediate resistance reaction to the disease (Table 13). The climbing bean lines (Table 13) selected as resistant had very little disease throughout the growing season. Immunity was observed only in a *Phaseolus coccineus* subsp. *polyanthus*, accession Guate 1076-CM and on progeny from crosses made between P. *vulgaris* and P. *coccineus*.

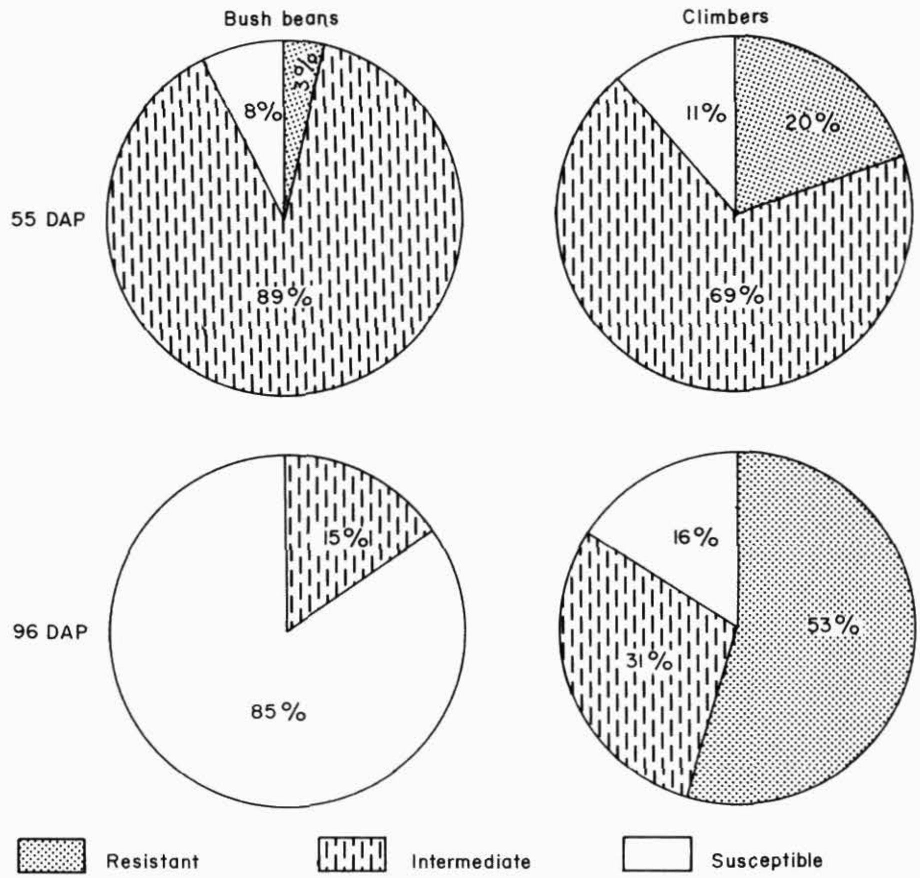

Figure 1. Percentage of bush and climbing varieties presenting resistant, immediate or susceptible reactions to inoculation with *Ascochyta phaseolorum* in Popayán.

Table 13. Selected bean varieties with intermediate or resistant reaction to ascochyta leaf spot under field conditions in Popayan, Colombia.

Climbing beans Resistant	Bush beans Intermediate
VNA 81006	Cena 163-1
VCB 81022	BAT 1481
V 08010	BAT 1486
G 10747	BAT 1569
G 12582	BAT 1615
VNA 81014	A 259
VNA 81013	EMP 117
	AS 2
	APN 6

Angular leaf spot, yield loss study. There is not general agreement among bean workers about the importance of the angular leaf spot pathogen (ALS) in yield losses. A study was conducted in Popayán, Colombia where breeding for resistance to ALS and anthracnose is carried out, to determine the yield reducing ability of ALS. The cultivar G 2858 susceptible to ALS but resistant to anthracnose was used. Susceptible spreader inoculated with a mixture of local isolates of the ALS pathogen, were distributed throughout the experimental plot. A standard experimental design was used and all treatments were replicated three times. The control plots were not inoculated or protected and a fungicide applied in seven different treatments at different dates after planting (Table 14). In all plots protected with the fungicide yields increased from 19% to 41%, suggesting that the ALS pathogen can depress yields of susceptible bean cultivars considerably. The fact that disease symptoms under natural conditions, often appear not long before or during flowering has lead many to believe that ALS does not reduce yields. Under field conditions in Popayán, the first disease symptoms on a early cultivar such as G 2858 often appear between 30-40 days after planting; however, if environmental conditions favor disease development, there is a very rapid increase in the number of lesions and of severity on the foliage and/or pods, accompanied by a general chlorosis and often a severe premature defoliation.

Table 14. Yield of bean cultivar G 2858 without protection and protected with a fungicide against angular leaf spot at Popayan.

Fungicide (days after planting)	Yield[a] (kg/ha)	Yield difference (%)
None	1118 c	0
26, 40	1491 abcde	21
40, 69	1496 abcde	25
40, 54	1591 abcd	30
54, 69	1375 bcde	19
26, 40, 54	1671 abc	33
40, 54, 69	1781 ab	37
26, 40, 54, 69	1903 a	41

a. Average of 3 replications; numbers followed by the same letter in the column are not significantly different (P = 0.05).

19800

Resistance to Virus Diseases

Screening for Common Mosaic Resistance

Screening of individual selections

The main activity of the Bean Virology section remains the screening of bean germplasm for common mosaic resistance. This year, an average of 620 plants were progeny-tested with selected strains of bean common mosaic virus (BCMV) per work day. The screening of climbing beans (BB III) was increased 50% over the number of lines evaluated last year (Figure 1). The evaluation of materials generated by the bean breeding II section of the Program was also increased, while the volume of materials screened for the bean breeding I section continued to decline as the backlog of breeding materials accumulated up to the creation of Bean Virology in 1978, has now all been evaluated.

Screening of selected grain types

The modifications introduced last year in order to detect symptomless, BCMV-susceptible materials before they are advanced for evaluation of other traits, made possible the identification of highly-prized red grain types such as "Calima", "Red Mexican", "Pompadour", and "Sangretoro", with dominant resistance to BCMV.

Since it has been frequently observed that some promising individual selections do not possess the dominant necrosis (I) gene which confers resistance to common mosaic, in a homozygous form, the Bean Virology section, as of this year, decided to take responsibility for the genetic purification and selection of lines homozygous resistant for the dominant alleles (II) of the necrosis (hypersensitive) gene. This recent modification in the general evaluation scheme has successfully resulted in the identification and selection of 11 homozygous BCMV-resistant lines with "Calima" grain type, and more than 15 lines with "Red Mexican", "Pompadour", red, and "Sangretoro" grain types. This represents the first report of the development of true red-mottled "Calima" grain types with resistance to common mosaic. Also, three of the BCMV-resistant "Red Mexican" lines identified and selected, have already been accepted for commercial production in Central America under the names "Chorotega", "Huetar", and "Corobicí," the latter also possessing tolerance to bean golden mosaic virus.

Collaborative Screening Projects

In the collaborative program of CIAT-IVT (Wageningen, Holland) F_3 and F_4 families carrying multiple resistance genes and originating from the first backcross of multiple-gene donors to tropically-adapted genotypes, were received from IVT and used as parents for 80 BC 2 populations. Progenies from the first backcross are much better adapted than earlier lines, facilitating further backcrossing and evaluation in tropical environments.

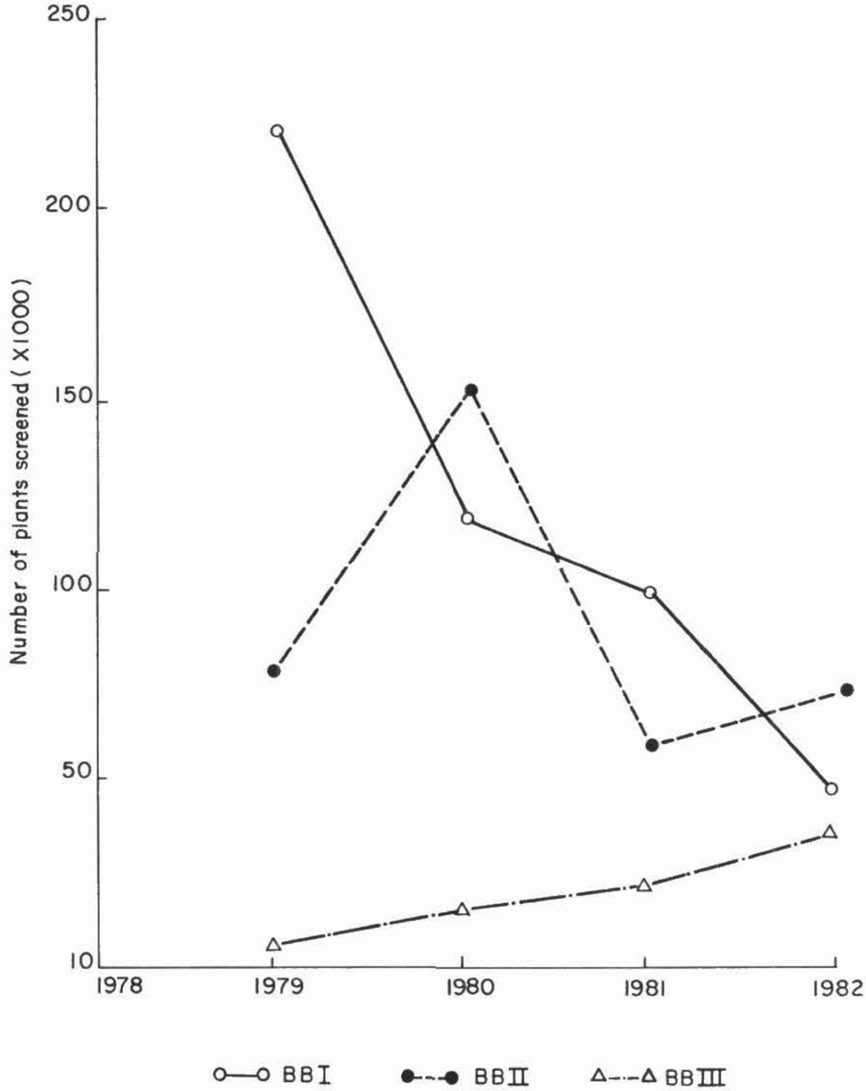

Figure 1. Common mosaic virus screening capacity and evaluation trends for bean breeding I (BBI), II (BBII) and III (BBIII)-generated materiales from 1978 to 1982.

Breeding for Golden Mosaic Virus

Breeding for resistance to bean golden mosaic virus began in 1975 with the evaluation of germplasm collections in Central America and Brazil. Hybrid varieties with black opaque seed and high levels of tolerance were selected in the ICTA-CIAT program. Progress in small-seeded red varieties for El Salvador and medium-sized red mottled determinate varieties for the Dominican Republic has been slower.

Results from the International Bean Golden Mosaic Virus Nursery (IBGMVN) of 1979 and 1980 (Table 1) were useful to identify non-black sources of resistance from hybrid lines produced in Colombia and Brazil. Additional crosses were made, and promising red-seeded selections are currently being tested in preliminary yield trials.

The release of Negro Huasteco 81 by the Instituto Nacional de Investigaciones Agropecuarias (INIA) of Mexico marked an exciting new level of interinstitutional effort. Negro Huasteco 81, highly tolerant to BGMV and of high yield potential, comes from a cross made by CIAT in Colombia, selected and progeny tested in Guatemala by ICTA, and subsequently introduced and further selected in Mexico as the Mexican national program initiated a BGMV breeding and selection program. Resistance to BGMV is of great utility for the gulf coast states of Tamaulipas and Veracruz, which are among the largest producers of black beans in Mexico. Efforts are underway to incorporate BGMV resistance into Canario and Azufrado grain types for the Pacific Coast of Mexico. Progress is slower due to BCMV susceptibility, the unique adaptational features of genotypes from this area, and the interaction with Empoasca and bean chlorotic mottle virus in reading BGMV symptoms.

Emphasis on secondary characters in BGMV breeding varies according to the grain type, as follows:

Black opaque - earliness, CBB, Empoasca, anthracnose
Small mottled - BCMV, CBB (heavy emphasis BGMV)
Canario, Azufrado - BCMV, rust (heavy emphasis BGMV)

Table 1. Summary of golden mosaic evaluations for best lines in 1979 and 1980 International Bean Golden Mosaic Virus Nurseries.

Identity	Guatemala	Londrina (Brazil)	Dominican Republic	Observations
DOR 15	7a*	7	6	Good 1979, interm-rust
DOR 47	7*	7*	6	
DOR 54	7	6*	6	
DOR 84	6	6	8	Good 1979
DOR 125	7*	7	0	Good 1979, red-seeded
DOR 145	7*	6*	6	
DOR 146	6*	6*	5	Sister of DOR 145
DOR 147	7*	6*	6	
DOR 152	6*	6*	6	
DOR 157	-	6*	5	
DOR 162	6*	6	7	
Aete 1/38	7	4*	7	

a. Evaluation scale of 1 = immune; 9 = highly susceptible.
* Noted for good/excellent adaptation.

the most promising black-seeded BGMV selections from recent cycles of intermating come from crosses made by ICTA in Guatemala, and from three-way crosses made by ICTA agronomists at CIAT for earliness and resistance to BGMV and other locally important diseases. Interesting sources of potentially unique resistance genes have been identified in routine BGMV evaluations of the EP nurseries, and these materials are being crossed with the most resistant progenies from earlier cycles of hybridization. A total of 221 BGMV crosses were made in 1982 for the four grain types listed above.

The International Bean Golden Mosaic Virus Nursery (IBGMVN) was extremely useful in the early stages of the BGMV project to identify germplasm bank accessions as parents for the hybridization program. The nursery evolved (Table 2) to accomodate hybrid selections from cooperating national programs, as well as interesting new sources of resistance genes. Results from the 1979 and 1980 IBGMVN (Table 1) suggest that very few entries were both resistant and adapted in three or more locations and in both years. Exceptions are DOR 15, DOR 84, DOR 125, and Aetê 1/38 (all good over locations and seasons), and DOR 54, DOR 146, DOR 147, DOR 152, and DOR 162 (all good over locations in the 1980 nursery). Argentina identified DOR 41 (ICTA Quetzal) from a set of IBGMVN lines. Countries such as Cuba Haiti, Jamaica, and Venezuela are able to regularly receive the best advanced lines without the expense of undertaking their own crossing and reselection program. Fifteen sets of the 1982-1983 IBGMVN have been shipped to date. One hundred and eight new DOR lines were coded in 1982.

A few hybrid populations from interspecific crosses made in Gembloux, Belgium, were evaluated previously for BGMV resistance in Guatemala. Survival and seed set was generally poor due in part to interspecific infertility and in part to the fact that P. coccineus parents are from cool environments and are poorly adapted to conditions of the Monjas, Guatemala nursery. Additional crosses have been made, but are being brought more gradually to hot, dry growing conditions while selecting for increased self-fertility.

Table 2. Evolution of the International Bean Golden Mosaic Virus Nursery (IBGMVN).

Year	Origin of entries: Germplasm bank	ICTA-CIAT program	National program	Total
1975	48	-	-	48
1976	71	-	-	71
1977	191	-	-	191
1979	5	127	13	145
1980	5	59	8	72
1982-1983	17	147	6	170

Research and Control of other Important Viral Diseases of Beans in Latin America

Bean chlorotic mottle

As reported last year, over 20,000 ha of small black and large white-seeded bean cultivars were severely affected in northwestern Argentina by a disease known as "achaparramiento" ("dwarfing"). Two successive investigations, financed by the Argentine National Institute of Agricultural Technology (INTA) at Famaillá, were undertaken by Bean Virology in the Provinces of Tucumán and Santiago del Estero. These field surveys led to the conclusion that the problem was primarily the disease bean chlorotic mottle, caused by a virus transmitted by whiteflies from wild hosts. The epidemics of the disease coincided with the expansion of soybean plantings in the area, which brought about a large increase of the whitefly population.

Due to the high demand for soybeans in the international market, only two control measures were compatible with the bean-soybean cropping systems: the introduction of chlorotic mottle-resistant varieties, and chemical control of the whitefly vector. Among the black-seeded materials sent by CIAT to Argentina, several lines, such as DOR 41, BAT 7, 304, 15, 58, and 64, have shown to possess varying degrees of resistance to chlorotic mottle. One line in particular, DOR 41 (ICTA Quetzal), has been found to be far superior in disease resistance, grain quality and yield when compared with the traditional "Negro Común", a varietal mixture planted in the affected areas. It is expected that DOR 41 will be adopted as a commercial variety soon after the current seed multiplication phase.

As for the large white-seeded type known as "Alubia" in Argentina, an active breeding project for chlorotic mottle resistance has been operating between CIAT, and the "Obispo Colombres" Experiment Station, and INTA. This year, a number of promising selections, such as Tucumana 4, 8, 16, and 20, were made in Argentina under heavy disease pressure.

In the meantime, the abandonment of "Alubia" bean production in areas with estimated yield losses of 100%, has been prevented with the application of systemic insecticides, applied at planting time, supplemented with foliar insecticide sprays according to whitefly population dynamics. The high price of "Alubia" in the market justifies the added cost of the chemical treatment.

Bean yellow mosaic

The significant process achieved by the Chilean National Institute of Agricultural Research (INIA) in the development of common mosaic-resistant cultivars, has been partially shaded by the increasing incidence of bean yellow mosaic virus (BYMV) in most bean growing areas of Chile.

The Bean Program is joining INIA in the fight against yellow mosaic by providing the national program with segregating populations derived from crosses made between selected Chilean cultivars and BYMV-resistant lines developed by the Plant Breeding Institute (IVT) in Wageningen, Holland. The crosses and resulting segregating populations sent to INIA can be observed in Table 3.

Table 3. Crosses made at CIAT between Chilean cultivars and bean common and yellow mosaic resistant experimental lines, and generations of segregating progenies sent to Chile for early evaluation.

Chilean cultivar	Parental IVT[a] lines					Limiting virus	
	7214	7233	80377	80338	80415	BCMV	BYMY
Negro Argel	F_2, F_3[b]		F_2				X
Orfeo-INIA				F_2			
Arroz-3	F_2, F_3					X	X
Seaway				F_2	F_2		X
Gratiot				F_2	F_2		X
Cristal Blanco		F_2, F_3				X	X
Tortola Diana	F_1, F_2, F_3	F_2, F_3					X
Cristal-Bayo			F_2		F_2	X	X
Bayos Titán	F_1	F_1, F_2					
Apolo	F_2	F_1					X
Hallados Dorados	F_2, F_3	F_2, F_3					X

a. IVT = Horticultural Plant Breeding Institute, Wageningen, Holland.
b. Generation sent to Chile.

The progenies of these specific crosses will also be evaluated for their resistance to necrosis-inducing strains of bean common mosaic virus, a potential problem in Chile, since some IVT experimental lines also possess resistance to these BCMV strains.

Continuing and Future Projects

The screening of selected grain types, such as "Calima" and other large reds, will continue in search of more and higher-yielding lines with resistance to common mosaic. Two grain types which will receive full attention next year will be the "Canario" for Peru, and "Cargamanto", the preferred cream-mottled climbing type in Colombia.

The incorporation of recessive genes which protect the dominant I gene presently exploited by the Program, against necrosis-inducing strains of BCMV, is the second most important project to be accelerated next year. Besides the IVT lines currently used, other recessive genes present in varieties such as "Great Northern 31" and "Red Mexican 35" will be selectively incorporated into I-gene-improved lines recently generated by the Program.

In the field of international cooperation, Bean Virology will assist the Chilean Natural Legume Program in the field evaluation of the segregating populations generated at CIAT, for their simultaneous resistance to bean common and yellow mosaic virus.

A golden mosaic project, pending approval, has also been advanced by the Agricultural Research Agency for Minas Gerais (EPAMIG) in Brazil, to recover important bean-growing areas of the State lost to bean golden mosaic virus (BGMV) in past years. CIAT is considered in this project proposal as source of BGMV-tolerant germplasm and technical assistance in the evaluation of nurseries. The project contemplates, primarily, the development of BGMV-tolerant cultivars other than the existing black-seeded grain types.

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Resistance to Insect Pests

Evaluations for plant resistance to *Empoasca kraemeri*, bruchids, and *Apion godmani* were continued. Germplasm evaluations for resistance to the desert spider mite were discontinued as largely empirical evidence suggested that the mite was not an economic pest.

Empoasca kraemeri

Breeding for resistance to *E. kraemeri* continued into the sixth and seventh cycles of crossing. A total of 183 F_2 populations were evaluated in 1982, and individual plant selections were made. Selections were made on the basis of apparent yield, seed color and size, architectural traits, plant growth habit, and maturity, as well as *E. kraemeri* resistance. Particular attention was paid to selecting plants with the type I growth habit (determinate), medium to large seed size, and red seeds as it has been difficult to incorporate resistance into these types of beans. In 1982, 21 additional EMP lines were coded bringing the total to 142.

Five-hundred accessions from the bean germplasm bank were evaluated for *E. kraemeri* resistance in 1982. About 11,000 of the 15,500 bank accessions which have been seed-increased have been evaluated for resistance so far. Germplasm evaluations will be accelerated to rapidly include more potential sources of resistance into the breeding program.

Mechanisms of Resistance to *E. kraemeri*

In the 1981 Annual Report it was reported that mechanisms other than tolerance might be partly responsible for the resistance of some lines to *E. kraemeri*. Further studies were conducted in 1982. In the greenhouse, it was found that although there were differences in preference for oviposition on bean plants seven days old when *E. kraemeri* was presented with a choice, these differences were not maintained when the pest was obligated to feed on any one line (Table 1).

However, paired tests with plants that were 20 days old showed that a difference in the number of eggs laid (measured as number of nymphs emerged) existed when the leafhopper was obligated to feed on one or another line (Table 2).

It is possible that *E. kraemeri* resistant lines contain different genes for resistance. A partial diallel study was conducted using five leafhopper-resistant lines as parents. The study was conducted in the field using natural populations of *E. kraemeri*. It was found that significant general combining ability existed for number of nymphs, total number of *E. kraemeri*, and the visual rating of damage (Table 3). Specific combining ability was not significant for any trait measured. These results indicated that resistance is additive.

Table 1. Preferences in oviposition of *E. kraemeri* on six bean lines.

Line	No. of *E. kraemeri* eggs per seedling	
	Choice	Obligate
EMP 81	14 a	27 a
EMP 82	10 ab	26 a
BAT 41 (control)	9 bc	25 a
EMP 94	9 bc	17 a
EMP 97	5 cd	26 a
EMP 89	4 a	24 a

Table 2. Preferences in oviposition of *E. kraemeri* on five resistant bean lines tested against BAT 41.

Resistant lines	Number of nymphs on resistant line vs. BAT 41
EMP 94	9 vs. 22**
EMP 82	23 vs. 36**
EMP 97	12 vs. 32**
EMP 89	11 vs. 17*
EMP 81	15 vs. 17

* Significant at 5% level.
** Significant at 1% level.

Table 3. Analysis of variance of a partial diallel genetic study using five *Empoasca* resistant bean lines as parental lines. Resistance traits were measured in the field under natural leafhopper infestations.

Source of variation	d.f.	Mean squares			
		Total leafhoppers	Adult	Nymphs	Visual damage
Replications	2	36.53 ns	11.99 ns	2.54 ns	1.11**
Crosses	9	28.04*	12.68 ns	5.80 ns	0.25 ns
G.C.A.	4	56.35**	19.03 ns	12.10**	0.68 **
S.C.A.	5	5.40 ns	7.59 ns	0.75 ns	0.22 ns
Error	18	10.98	7.88	3.33	0.14

* Significance at 5% level.
** Significance at 1% level.

Bruchids

In the Annual Report of 1981 data on resistance of wild bean accessions to the Mexican bean weevil, Zabrotes subfasciatus, were presented. In 1982 even higher levels of resistance were found to the common bean weevil, Acanthoscelides obtectus (Table 4). Two accessions, G 12953 and G 12952 were resistant to both bruchids. Resistance consisted of increased life cycle of the pests, increased mortality, lower adult weight, and reduced oviposition. Under continuous rearing of the pests for successive generations on resistant accessions, A. obtectus died out on accession G 12866 after one generation and on G 12949 and G 12952 after two generations (Table 5).

Small seed size was generally associated with resistance. The correlation coefficients (r^2) between seed size versus number of eggs, number of adults emerged, adult weight and length of development period for Z. subfasciatus were 0.64, 0.69, 0.63, and -0.42, all significant. For A. obtectus the r^2 values between seed size versus number of adults emerged, adult weight, and length of development period were 0.56, 0.64, and -0.42, all significant.

A. obtectus is capable of infesting seed in the field before it is harvested. The adult female perforates the dry pod walls and deposits eggs inside. In tests where adults had no choice between accessions, less eggs were laid in the resistant accessions than in the control, Diacol Calima (Table 6). Less seeds per pod were perforated by the larvae in resistant accessions (Table 6).

Table 4. Levels of resistance to A. obtectus in nine resistant wild types of beans as compared to susceptible cultivated varieties (average of 5 replicates 50 seeds each infested with 50 eggs).

Accession	No. adults/ replications	Days until emergence	Emergence (%)	Dry weight/ adult (mg)	Weight 100 seeds (g)
G 12862B	1.0 a	36.7 de	2.0 a	1.5 ab	5
G 12866	1.0 a	42.0 cd	2.0 a	2.0 bcd	5
G 10019	1.8 a	36.1 e	3.6 a	1.3 a	5
G 12949	2.0 a	62.5 a	4.0 a	2.0 cde	7
G 12952	5.6 a	61.5 a	11.2 a	1.6 ab	6
G 12953	8.6 a	63.0 a	17.2 a	1.6 ab	6
G 12891	15.8 b	52.1 b	31.6 b	1.8 bc	8
G 12942	17.8 bc	40.4 cd	35.6 bc	2.4 def	17
G 12929	23.0 cd	42.6 c	46.0 cd	2.1 cde	12
ICA-Bunsi	30.2 de	35.5 e	60.4 defg	2.9 gh	18
Diacol Calima	29.2 de	36.6 e	58.4 defg	2.6 fg	50

Table 5. Number of progeny adults emerged in continuous rearing of *Zabrotes subfasciatus* and *A. obtectus* on selected resistant wild bean accessions and a susceptible variety. Each successive infestation was made with the first seven emerged pairs of *Z. subfasciatus* or first 50 eggs of *A. obtectus* of the previous generation in five replicates.

CIAT accession	Generation No. 1	2	3	4	5
Z. subfasciatus					
G 12953	20.8 a	31.2 a	16.2 a	18.2 a	21.8 a
G 12952	23.4 a	28.6 a	27.6 a	29.2 a	30.0 a
G 10019	93.4 a	116.8 ab	110.6 ab	139.8 b	146.0 b
G 12891	137.8 a	152.0 a	162.6 a	145.6 a	160.6 a
G 12939	150.4 a	238.8 b	231.0 b	236.8 b	246.0 b
Diacol Calima	247.8 a	348.2 b	331.4 b	341.4 b	349.0 b
A. obtectus					
G 12866	3.0	0	-		
G 12891	11.0	16.6	18.0		
G 12942	13.2	14.4	16.2		
G 12949	3.4	1.0	-		
G 12952	5.6	1.7	-		
Diacol Calima	37.4	19.8	44.6		

* Data followed by the same letter in horizontal columns are not significantly different ($p < 0.01$).

Table 6. Adult *A. obtectus* oviposition and larval penetration in pods of resistant and susceptible bean lines.

Line	Adult penetration[a]: No. holes/pod	Adult penetration[a]: No. eggs inside pod	Larval penetration[b]: No. perforated seeds/pod
G 10011	2.5 bcd	60.4 b	0.5 a
G 11056	2.3 cd	32.8 b	2.0 ab
G 12949	1.9 d	36.8 b	0.6 a
G 12952	3.8 abc	57.1 b	0.5 a
G 12953	4.0 ab	62.3 b	0.6 a
Diacol Calima	5.0 a	136.4 a	3.4 b

a. Four pairs of adults per six pods.
b. 50 eggs per six pods.

F_2 seed from crosses using sources with high levels of resistance to both bruchids are presently being evaluated and selected (Table 7). Additional crosses are currently being made to include other seed and plant types.

Apion godmani

In 1982 *A. godmani* nurseries comprised of 40 materials each were sent to eight sites in Central America. As of this date, data on one of the nurseries in Honduras has been reported. As in 1981, several of the materials demonstrated high levels of resistance compared to the control, Desarrural (Table 8). Data from Honduras, Guatemala, and Mexico are in general agreement, indicating that there is little genotype by environment interaction.

The target area for *A. godmani* resistance is from northern Nicaragua to Central Mexico and in altitudes from 500 to 2000 masl. Resistance is needed in small black opaque and small red brilliant beans of plant growth habits II, III, and IVa.

Table 7. Crosses made in breeding for resistance in beans to bruchids.

Crosses[a]	*A. obtectus*[b]	*Z. subfasciatus*[b]	Weight of 100 seeds (g)
1) BAT 1225 (S) x G 10019 (R)	R	S	14
2) BAT 1225 (S) x G 12952 (R)	R	R	14
3) BAT 1235 (S) x G 10019 (R)	R	S	10
4) BAT 1235 (S) x G 12891 (R)	R	I	15
5) BAT 1235 (S) x G 12952 (R)	R	R	19
6) V 7920 (S) x G 12891 (R)	R	I	15
7) V 7920 (S) x G 12952 (R)	R	R	14
8) V 8030 (S) x G 10019 (R)	R	S	14
9) V 8030 (S) x G 12891 (R)	R	I	14
10) G 10019 (S) x G 12891 (R)	R	I	9
11) G 12952 (R) x G 12891 (R)	R	I	9
12) G 12597 (S) x G 12952 (R)	R	R	13
13) G 12722 (S) x G 10019 (R)	R	S	22
14) G 10019 (R) x Carioca (S)	R	S	10
15) G 12891 (R) x G 4017 (S)	R	I	10
16) G 12891 (R) x Cargamanto (S)	R	I	19
17) G 12891 (R) x G 12952 (R)	R	I	5

a. S = susceptible to both bruchids; R = resistant to at least one bruchids.

b. R = resistant to the mentioned bruchid; I = intermediate; S = susceptible.

Table 8. Damaged caused by *Apion godmani* in selected lines (Honduras, 1982).

Line	Damaged pods (%)	Damaged seeds (%)
BAT 947	6	2
EMP 87	3	1
EMP 86	9	2
APN 71	5	2
APN 70	3	2
APN 38	1	0
APN 42	0	0
G 11506	0	0
Desarrural (control)	28	13

19802

Plant Architecture and Yield

Component Analysis

Recently, CIAT bean breeders have become increasingly interested in the exploitation of architectural traits as a source of variation for improved disease avoidance, grain quality, lodging resistance and yield. However, knowledge of how the environment can alter both plant morphology and its relationship to yield is a necessary prerequisite to the development of effective breeding strategies. Thus, concurrent with the development of individual lines with specific architectural amendments, we initiated several experiments to study the strength and stability of the relationships between architectural components and yield. A brief summary of the first of these studies is presented here. The objective of this experiment was to study the response of yield and architectural components to environments and planting densities.

The cultivars chosen to represent each bush bean growth habit (I, II, and III) included traditional cultivars as well as lines which had been recently developed to exploit one or more architectural components. For example, A 132 was included because it possesses multiple branching and short internodes, A 57 has upright branching, and A 55 has reduced lateral branching. All cultivars were grown in replicated trials at Quilichao, Popayan and in two seasons at Palmira. Plant densities of 5, 13.3, 21.6, and 30 plants/m^2 were achieved by varying the within-row spacing. The between row spacing was 60 cm. In all locations regular applications of chemicals were used to control insects and diseases.

Considerable variation for yield and architectural components was observed among cultivars within growth habits; and in addition, habit means were significantly different for all traits, except for the number of lateral branches/plant between habits II and III (Table 1). Moreover, there were consistent trends towards increased habit mean performance for all traits except for the number of lateral branches per plant, with increasing indeterminancy. Type I determinate varieties had relatively higher number of lateral branches than indeterminate types II and III.

Significant differences among locations and between planting dates within the Palmira location were observed for yield and architectural components (Table 2). In addition, cultivar x location interactions were significant for yield and all architectural components, indicating that some cultivars were better adapted to specific locations; however, 3 of the 4 habit III cultivars, A 70, A 231, and Carioca, were among the highest yielders across all locations. These three cultivars also tended to have among the highest values for most architectural components, except for lateral branches/plant. These results suggest that the balance of architectural characteristics of some habit III cultivars may provide enhanced "buffering" against environmental fluctuations resulting in broader adaptation.

Table 1. Cultivar means over locations and planting densities for grain yield and several architectural components.

Cultivar	Yield[a] (g/m^2)	Nodes/ m^2	Lateral branches/ plant	Nodes/ lateral branch	Nodes on main stem	Main stem internode length (cm)
Habit I						
A 57	147	343	4.5	2.6	9.6	4.1
A 132	129	394	5.4	2.9	9.2	2.7
A 475	141	478	5.1	3.8	11.0	3.4
ICA L-24	166	321	4.2	2.7	8.9	3.8
Mean	146	383	4.8	3.0	9.7	3.5
Habit II						
A 55	149	272	2.5	2.1	11.7	4.3
A 156	176	727	6.8	4.6	16.1	2.9
BAC 43	153	343	3.2	3.5	10.1	5.0
ICA-Pijao	167	415	3.4	3.6	13.9	4.7
Mean	161	439	4.0	3.5	12.9	4.2
Habit III						
A 22	148	518	3.9	4.7	14.0	6.4
A 70	192	400	3.6	3.6	12.4	6.1
A 231	178	518	4.3	4.5	14.9	3.8
Carioca	215	483	4.0	4.3	13.5	6.2
Mean	183	480	3.9	4.3	13.7	5.7
Cultivar LSD[b]	14.0	30.0	0.3	0.3	0.4	0.8
Habit mean LSD	7.0	16.0	0.2	0.2	0.2	0.5

a. Corrected for 14% moisture.
b. Waller-"Duncan K-ratio T-test within columns (K = 100).

The average response curves for grain yield with increasing plant density were parabolic in nature for indeterminate habit II and III cultivars, i.e., they rose to maximums at 22.4 and 24.0 plants/m^2 for habit II and III respectively, and then declined (Figure 1). In contrast, the average response curve for determinate habit I cultivars was asymtotic in nature, i.e., it rose to a maximum and then remained relatively constant (Figure 1).

Table 2. Means over cultivars and planting densities for grain yield and several architectural components at the test environments used.

Environment	Yield[a] (g/m^2)	Nodes/ m^2	Lateral branches/ plant	Nodes/ lateral branch	Nodes on main stem	Main stem internode length (cm)
Palmira I[a]	89	295	2.9	2.2	11.7	4.0
Palmira II[b]	137	484	4.5	3.9	12.9	4.9
Popayan	204	430	4.0	4.0	11.2	4.5
Quilichao	224	529	5.5	4.2	12.7	-
LSD[c]	82	131	1.5	1.2	0.9	0.8

a. Planted March 25, 1982.
b. Planted June 24, 1982.
c. Waller-Duncan K-ratio T-test (K = 100).

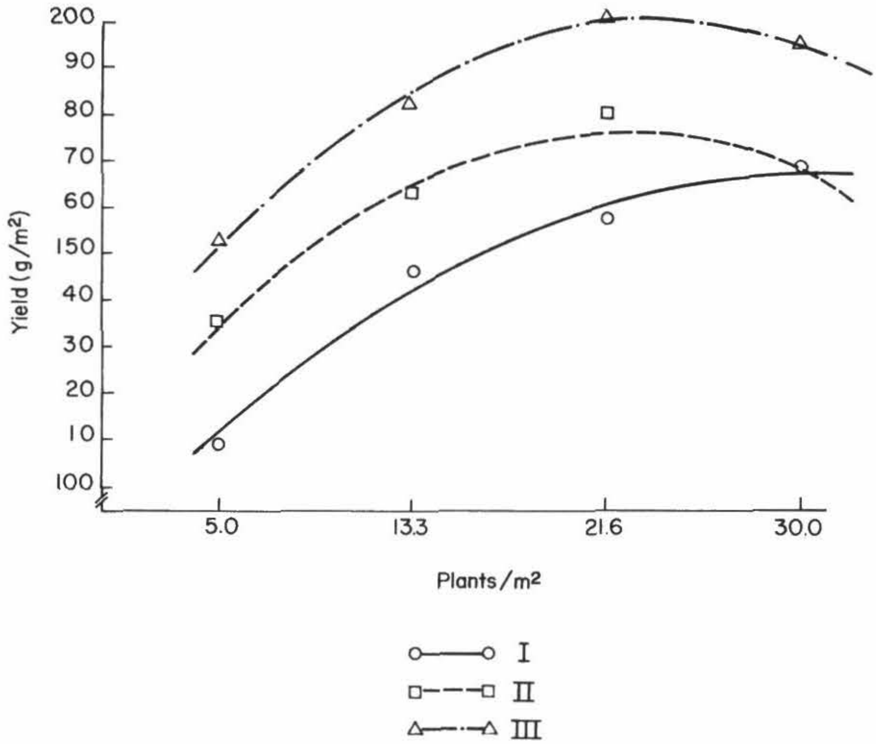


Figure 1. Effect of increasing plant density on the mean yield of four cultivars within each of three bush bean growth habits. ($S\bar{y}$ = 5.4).

Significant linear increases in nodes/m^2 with increasing plant density were observed for all three growth habits (Figure 2). The continued increases in nodes/m^2 at densities beyond the yield maximums indicates that a decreasing percentage of nodes were productive at higher plant densities.

The average linear reductions in lateral branches/plant and the shape of the curvilinear reductions in nodes/lateral branch with increasing plant density were similar for indeterminate habit II and III cultivars, which in turn were different from the response curve for determinate habit I cultivars (Figures 3 and 4).

Contrasting response to increased plant density were also observed between determinate and indeterminate cultivars for nodes on the main stem and main stem internode length (Figures 5 and 6). Linear reductions in nodes on the main stem were similar for habit II and III cultivars, whereas no reduction was observed in habit I cultivars. In contrast, main stem internode length increased in habit I cultivars with increasing plant density, but was unchanged in habit II and III cultivars. The combined effect of the differing responses to these two traits results in determinate plants becoming taller and indeterminate plants shorter with increasing plant density.

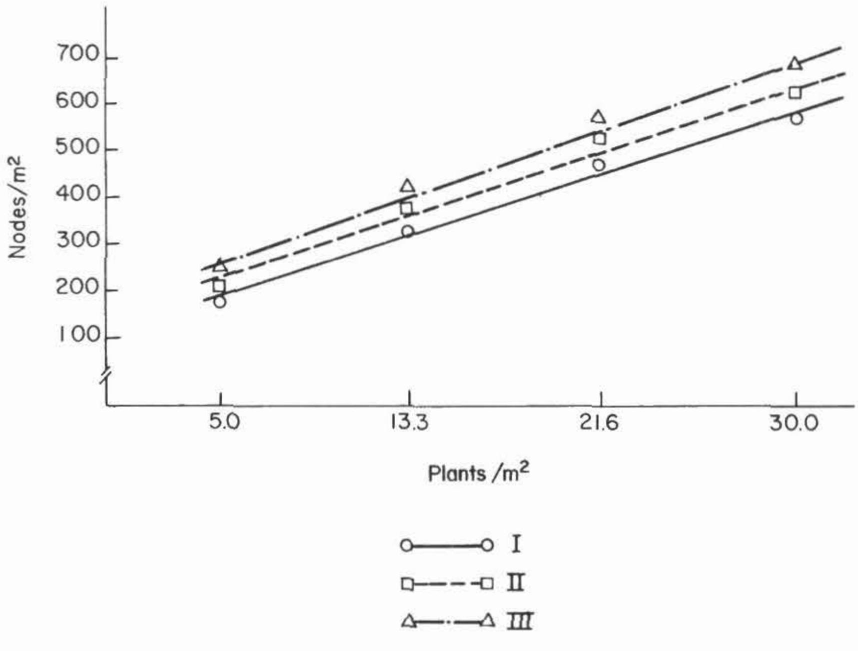


Figure 2. Effect of increasing plant density on the mean number of nodes/m^2 of four cultivars within each of three bush bean growth habits. ($S\bar{y}$ = 12.8).

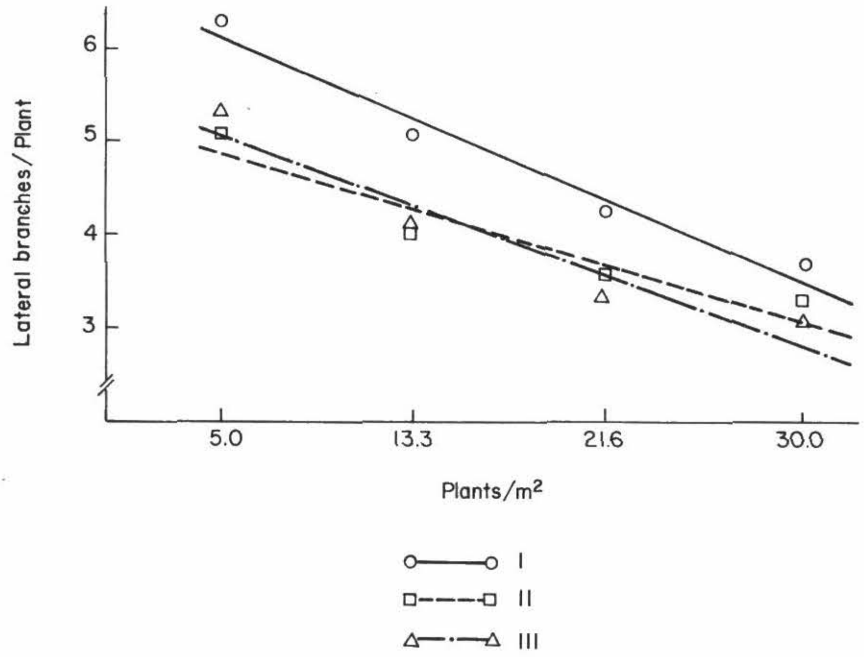


Figure 3. Effect of increasing plant density on the mean number of lateral branches of four cultivars within each of three bush bean growth habts. ($S\bar{y}$ = 0.15).

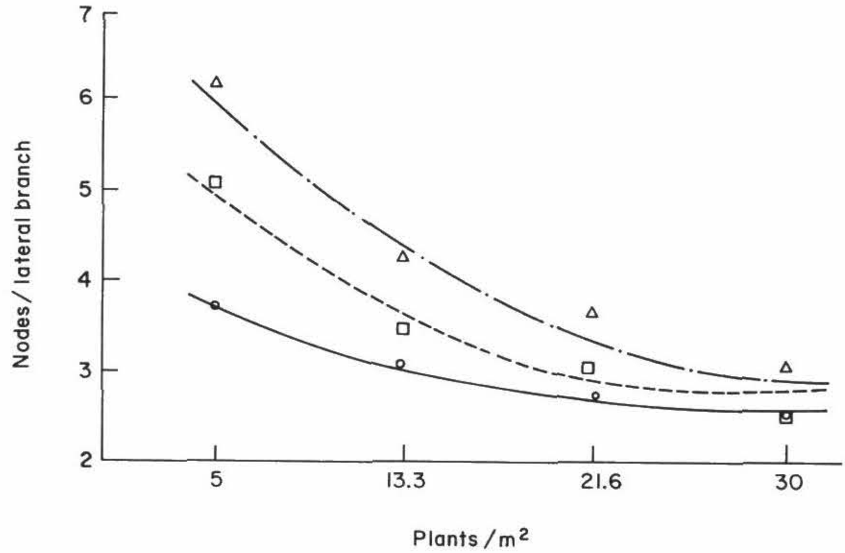


Figure 4. Effect of increasing plant density on the mean number of nodes/lateral branches of four cultivars within each of three bush bean growth habts. ($S\bar{y}$ = 0.15).

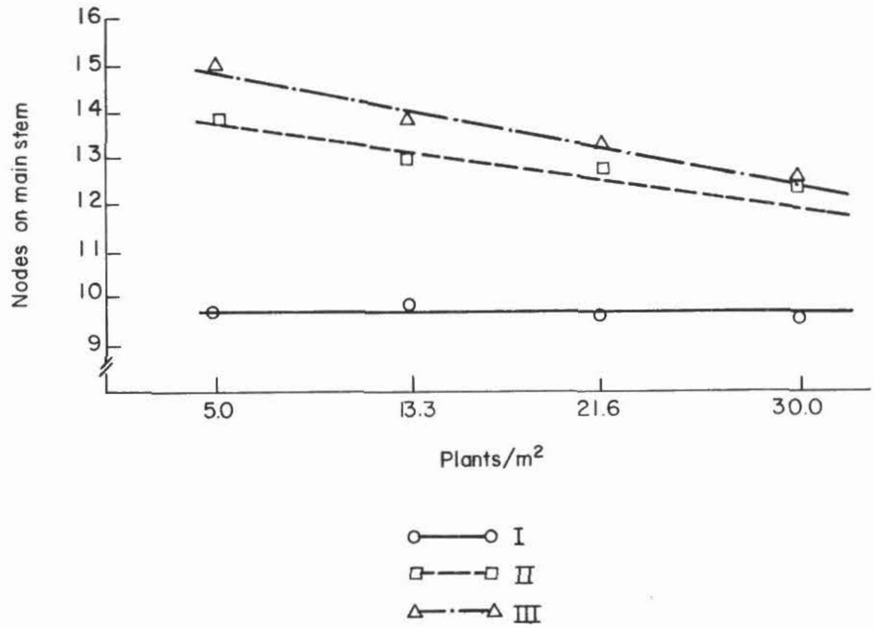


Figure 5. Effect of increasing plant density on the mean number of nodes on the main stem of four cultivars within each three bush bean growth habits. ($S\bar{y}$ = 0.19).

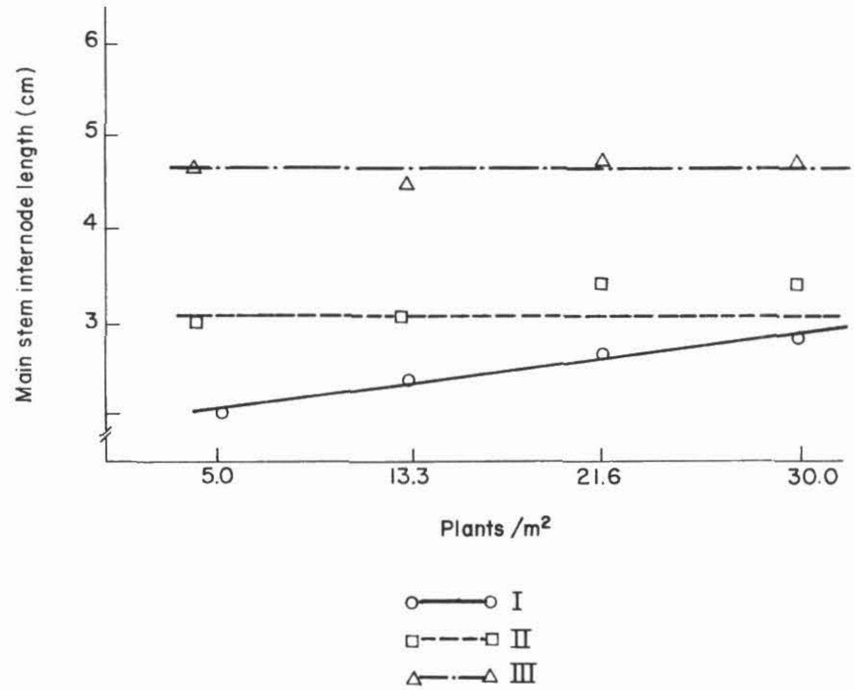


Figure 6. Effect of increasing plant density on the mean main stem internode length within each of three bush bean growth habits. ($S\bar{y}$ = 0.13).

Phenotypic correlations between architectural components and grain yield within growth habits ranged from medium to low, suggesting that the addition of no one architectural component alone will result in significantly increased yields (Table 3). Furthermore, the correlation between yield and days to flower in habit I, and nodes on the main stem in habit II, and main stem internode length in habit III were altered in response to plant density. Similarly, the correlation between yield and nodes/lateral branch and main stem internode length were altered in response to location (Table 4). The failure of these traits to maintain consistent relationships with yield over given densities or environments suggests that environmental rather than genetic effects prevail in the expression of their phenotypic correlations. This has important implications for breeding strategies because it suggests that indirect selection for increased levels of these architectural components will not necessarily result in increased yield across environments.

In conclusion, the results of this study indicate that both environments and planting densities have significant effects on yield performance and on the expression of architectural components. Thus, plant breeders choosing to exploit architectural variation must be cautious of selection under conditions of variable inter-plant competition. In addition, selection of broadly adapted cultivars which maximize yield or architectural component expression must be done over a wide range of target environments. The questions still remain as to which set of architectural components will most contribute to yield, and how to best combine those traits in commercially acceptable cultivars. Notable is the ability of some habit III cultivars to have consistently higher yields regardless of the environment, and their enhanced ability to compensate for reduced plant density. Greater emphasis has already been directed towards exploiting the architectural characteristics of this habit; however, the major limiting factor has been the slow progress in combining habit III architecture and yielding ability with the more desirable large grain sizes.

The products of the next series of experiments should provide us with greater knowledge of how the components of plant architecture shift towards optimum levels during the expression of maximum yield. However, the challenge in future breeding efforts is to develop strategies for increasing yield combining optimum architectural expression in currently available habit III cultivars as well as raise the yield potential of large seeded cultivars to the level of small seeded indeterminate varieties.

Breeding

The second cycle of breeding for architectural and yield improvement is well underway. The best lines selected from the first cycle were crossed among themselves and to the highest yielding and disease resistant lines from various other sources. Several hundred F_3 progenies were tested at CIAT-Palmira, Quilichao and Popayan farms. There is strong indication that the lines coming out of the second cycle while maintaining their level of architectural traits may outyield their parents, especially in type I. However, in order to assess their yield quantitatively about 130 F_3 families, rather uniform for growth habit, grain type, etc., were bulk harvested. The replicated yield trial will be conducted in the March planting of 1983.

Table 3. Phenotypic correlations between various architectural components and grain yield for three growth habits of beans grown at two within row densities.

Architectural component	Growth habit I, plants/m^2: 5	I: 30	II, plants/m^2: 5	II: 30	III, plants/m^2: 5	III: 30
Days to flower	.00	.42**	.04	.18	.01	.00
Nodes/m^2	.38**	.31*	.42**	.34*	.57**	.57**
Lateral branches/m^2	.35**	.15	.51**	.33*	.45**	.60**
Nodes on main stem	-.04	.08	.01	.37**	-.11	.22
Nodes/lateral branch	.37**	.38**	.50**	.31*	.67**	.50**
Main stem internode length	.61**	.62**	.51**	.40**	.21	.38*

* Significant at .05 level.
** Significant at .01 level.

Table 4. Phenotypic correlations between various architectural and grain yield in four environments.

Architectural component	CIAT 1	CIAT 2	Popayan	Quilichao
Days to flower	.06	-.17*	.07	-.06
Nodes/m^2	.60**	.40**	.44**	.30**
Lateral branches/m^2	.31**	.25**	.37**	.23**
Nodes on main stem	.17*	.15	.20*	.15
Nodes/lateral branch	-.10	.34**	.05	-.09
Main stem internode length	.33**	.66**	.10	.49**

* Significant at .05 level.
** Significant at .01 level.

19803

19803

Tolerance to Drought Stress

Drought trials were sown in CIAT during both the January/February and July/August dry periods in 1982. However, as happened before, the early dry period was not to be relied upon and the trials of that season were discarded as receiving insufficient stress to discriminate the materials.

As from this year the screenings have been divided into two stages. Stage one is a preliminary screening using a check variety sown in strips across the experimental lot as a comparison for each plot. Canopy temperature differential was taken between each plot and the adjacent check strip using an infrared thermometer. Ninety six lines from 1981 EP were screened in this preliminary stress screening. The experiment is designed to handle large numbers of materials and it is hoped in the future to include all of the EP and new materials coming from the drought tolerance breeding program. No irrigation control plots were used. The second stage screening was a trial using irrigated control plots adjacent to each stress plot as in previous years but with the number of materials reduced to increase the precision of the trial. Seventy two promising materials were included in stage 2. Thirteen materials were common between the two trials, which were sown at the same time adjacent to each other in the same lot in CIAT.

The best entries in each growth habit group for the stage 1 screening are summarized in Table 1. There is a striking relationship between the yields of the best lines in each group and the growth habit. This is also the case for the group mean yields. These are 417, 482, 695, and 1152 kg/ha^{-1} for the mean yields of habits I, II, III, and IV respectively. All are significantly different from the other three except between habits I and II (see Table 2). This would appear to indicate a strong relationship between yield under stress and plant size and vigor, which generally increase in the same sequence.

Canopy temperature differential appears to follow the inverse trend, being highest in type I materials while lines of climbing type IV habit in some instances showed cooler canopies than the check variety G 5059. This is not due to different canopy structure in the climbers as for this trial they were not grown on supports, but left to trail on the ground, producing a canopy much like a type III. The relationship between canopy temperature (Δt) and yield is marked (Figure 1), the type IV materials are clustered in the top left corner. This would indicate that those plants which yielded best were able to maintain their transpirational water flow. It is conjectured that the rooting depth is a major factor in this effect and that plant size and vigor have considerable bearing on this.

An illustration of the possible effect of rooting depth is given in Figure 2 in which the water budget for the experiment was calculated assuming two distinct rooting patterns. The first to a depth of about 1.2 m yielding an available soil water capacity of 200 mm, the second with an effective rooting depth of 0.5 m giving approximately 80 mm of available water. It is clear from the plot of E_A/E_t, (Figure 3) (actual evapotranspiration over potential evapotranspiration: a commonly used index of plant stress) that the deep rooted plants could grow through the experimental period with little serious stress, whereas restricted rooting depth brought on severe stress. The extreme rooting patterns assumed have been observed in beans sown in the CIAT station.

Table 1. Stage 1 Screening. The four most drought tolerant lines per growth habit, and lines outperforming the check G 5059.

	Yield	T	Color
Type I (20 entries)			
A 195	1060	1.54	Cream
BAT 1251	872	2.37	Purple
BAT 1274	855	2.23	Brown
A 186	740	3.74	Cream
Group range	69-1060	1.54-4.16	
Type II (41 entries)			
BAC 63	1377	0.87	Cream
BAT 1217	1316	0.28	Red
A 59	1273	1.26	Coffee
BAT 1155	1147	1.98	Red
Group range	71-1377	.28-3.94	
Type III (15 entries)			
A 147	1501	1.34	Cream
BAT 1198	1490	0.59	White
A 162	1327	0.71	Cream
BAC 38	1081	1.30	White
Group range	116-1501	.40-3.30	
Type IV (20 entries)			
V 8024	1757	0.11	Coffee
V 7918	1518	-0.29	Purple
V 8017	1512	0.73	Black
V 8025	1506	0.05	Black
V 8010	1466	0.30	Black
V 8014	1459	-0.49	Black
V 8016	1380	0.55	Black
V 8030	1278	-0.91	Black
V 79119	1272	-0.33	Red
V 8012	1259	1.06	Black
Group range	791-1757	-0.9-1.06	
SE	224	.96	
CV	32.8	50.0	
G 5059 (check)	1253	-	Cream

Table 2. Mean yields under stress EP 81, by growth habit.

Habit	Mean yield	No. obs.	LSD (5%)
I	417	20	
			79.5
II	482	41	
			83.7
III	695	15	
			105.0
IV	1152	20	
G 5059 (check)	1253		

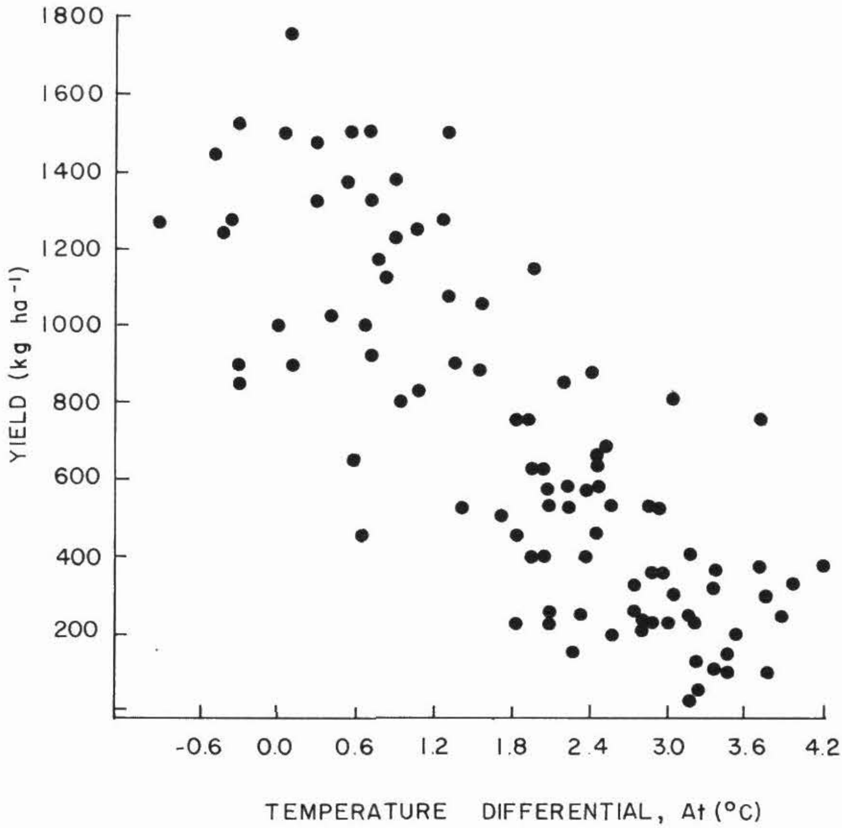


Figure 1. Stage 1 Screening. Plot of yield against temperature differential between test plot canopies and the check variety (G 5059).

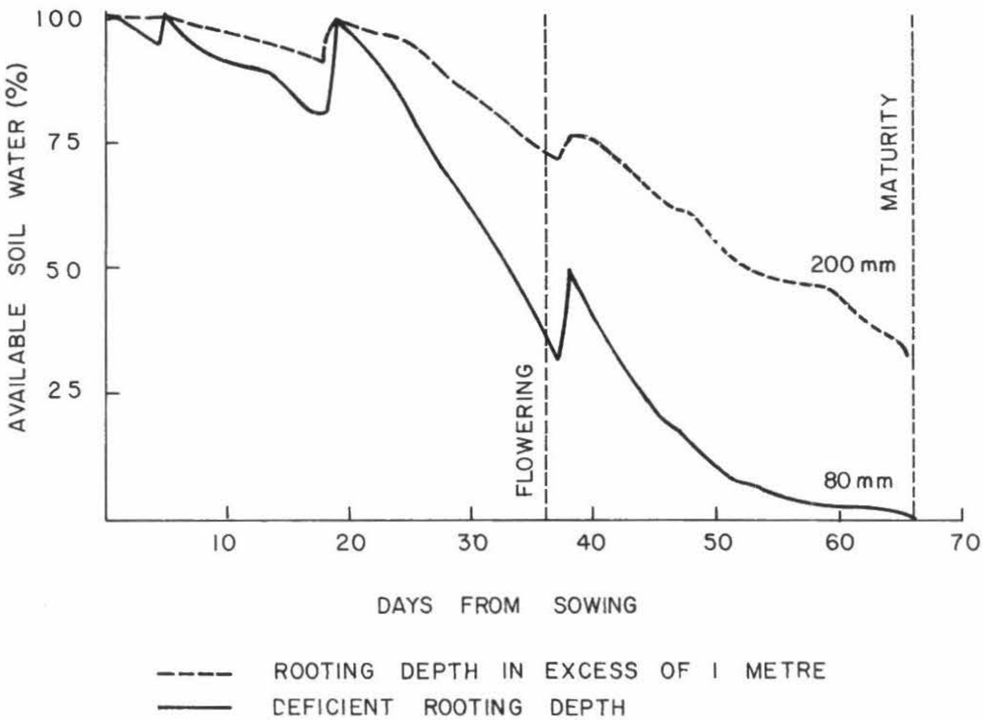


Figure 2. Estimated soil water budgets for drought trials.

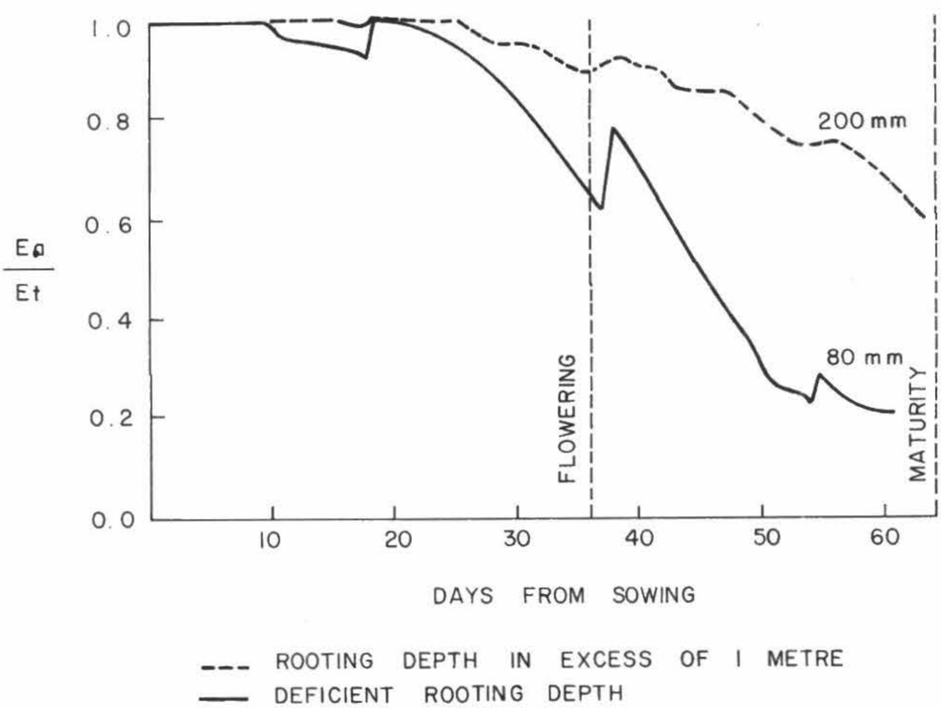


Figure 3. E_a/E_t estimated for drought trials.

The verification of this conjecture would greatly help in the early selection of candidates for drought tolerance by vegetative characteristics. This must however wait until a full time physiologist is employed by the program.

Stage 2 screening employed the chain block design as in previous years and included an irrigated control. Thirty three of the 72 materials tested were kept over from the previous screening trials. Of these, 14 were present in the top twenty varieties (see Table 3), six only were new entries. With the exception of the very good new material EMP 105, red seeded materials are poorly represented in the better lines. BAT 258 occupies exactly the same position as in the previous year trial with no others in near reach of the leaders. However, a few new materials have entered the list with respectable yields, albeit at much lower levels than the leading cream and black lines; Table 4 lists the five best. Apart from EMP 105 none are significantly above the experimental mean, but are the best in their group.

The relationship between stress yield and control yield is generally positive and strong, however, the degree of correlation depends on the degree of stress. In lightly stressed trials, the correlation may be very high, for this reason such trials are discarded. In well stressed trials such as those under discussion there still exists a positive relationship because of the asymmetry of the response. A poor yielder in control cannot by definition give a good yield under stress. Figure 4 shows however that given sufficient stress a fair number of very high yielding lines may fall to unacceptable yield levels under stress.

Comparison of the stages 1 and 2 trials can be made with confidence. The two trials ran concurrently in the same experiment lot and the 13 joint materials yielded very similar stress yields in both. The comparison leads to a disappointing conclusion. There is only one EP 81 entry which approximates the performance of the previously identified tolerant materials tested in stage 2. Figure 5 shows the relative distribution of lines in the two trials. This observation is based on only one pair of trials and so much be viewed with caution. It is rather unfair to blame the EP 81 for not producing additional drought tolerant material since none of the materials tested therein have been purposely screened for drought. The situation will undoubtedly improve when the breeding lines from the first crosses of the drought tolerance project start to enter the testing system, but this will do nothing to widen the genetic base of the breeding project which must relay on new materials coming in from EP.

Table 3. Performance of best lines in stage 2 drought screening 1982.

CV	Stable yield[a]	Control yield	Stress yield	Δt	Habit	Color
BAT 322	2782	2904	2665	1.45	II	Cream
BAT 868	2720	3126	2383	1.29	II	Coffee
BAT 85	2684	3115	2321	2.21	II	Cream
BAT 336	2672	3611	2008	4.91	II	Cream
BAT 256[b]	2659	3106	2288	2.34	II	Cream
BAT 1210	2657	3510	2004	2.82	II	Cream
						[c]
EMP 84[b]	2589	3699	1816	2.47	II	Black
G 4525	2587	3336	2006	3.96	II	Black
EMP 105[b]	2587	3122	2165	2.03	II	Red
BAT 125	2556	2958	2211	1.03	II	Cream
G 4446	2517	2907	2188	1.88	III	Coffee
G 5201	2516	2986	2126	3.07	I	Black
BAT 477	2495	2875	2187	2.65	III	Cream
A 114[b]	2469	3484	1747	1.90	III	Cream/mottled
EMP 86[b]	2393	3099	1904	3.37	II	Cream
A 170	2384	3353	1700	2.89	II	Cream
BAT 1257[b]	2380	3212	1765	2.82	III	White
G 4454	2340	3151	1756	3.50	II	Black
						[d]
BAT 258	2289	3073	1741	1.82	II	Red
Mean	1970	2812	1451	3.17		
SD	325	400	348	0.83		
CV (%)	16.5	14.2	24.0	26.2		
G 5059 (check)	2213	2814	1755	2.41	II	Cream

a. Geometric mean of stress and control yield (in kg/ha).
b. Indicated new entry.
c. Cutoff at mean + 2 standard deviations.
d. Cutoff at mean + 1 standard deviation.

Table 4. The best red seeded materials in stage 2 drought trials, 1982.

	Stable yield	Control yield	Stress yield	Δt	Habit
EMP 105	2587	3122	2165	2.03	II
BAT 258	2289	3073	1741	1.82	II
BAT 1232	2280	3077	1703	1.91	II
BAT 1289	2199	3106	1560	4.23	III
BAT 1102	2193	3385	1424	4.41	III

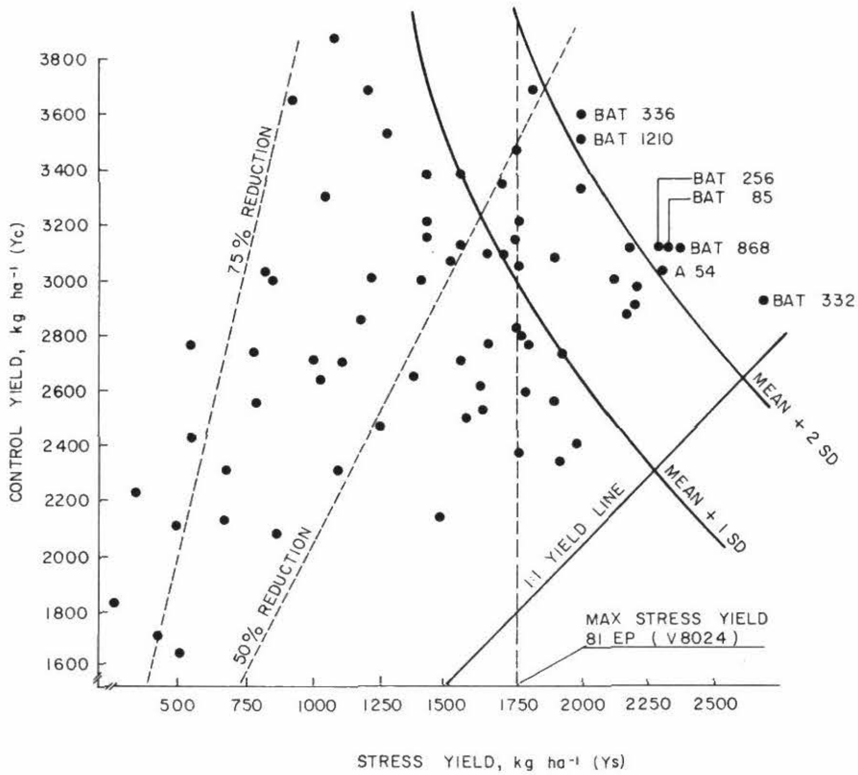


Figure 4. Stage 2 Screening. Control yield vs stress yield for 72 lines tested. Contours show the cutoff levels for selection using the index $I = \sqrt{Y_s \cdot Y_c}$ at the levels indicated.

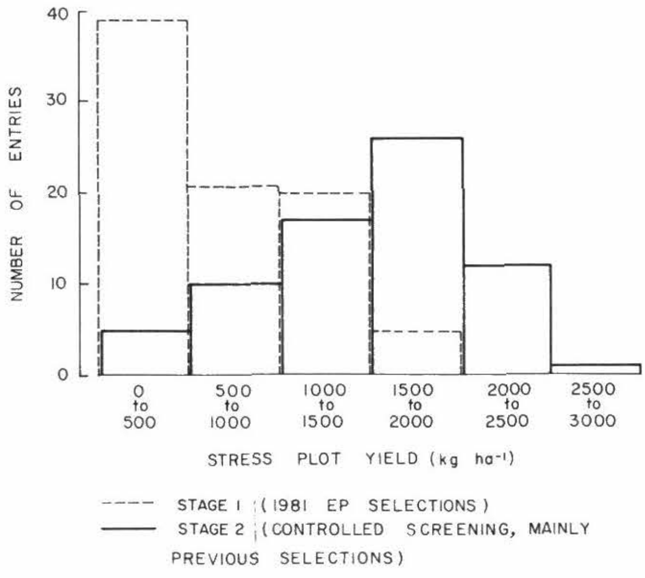


Figure 5. Number of entries achieving the indicated stress yield in drought trials.

19804

Wide Adaptability to Photoperiod and Temperature

While response to photoperiod has been widely recognized as an important determinant of varietal adaptation in bean growing regions at higher latitudes, the development of CIAT lines is largely carried out under nearly constant equatorial daylengths in which sensitivity to photoperiod is not expressed. Relatively few of the Germplasm Bank accessions, or parent materials used in the bean breeding program have been evaluated for their response to long photoperiods, and international trials at higher latitudes have consequently included some lines which were unacceptably delayed in maturity.

A structure of incandescent lights in the field at CIAT has permitted the evaluation of response to daylength of parental materials, advanced progenies and, to some extent, early generation segregating populations, in order to produce materials with a greater likelihood of suitable adaptation in growing areas more distant from the equator. Smaller light structures have also been erected at the CIAT station in Popayan (1850 m), and the ICA station at Obonuco (2710 m) and are being employed in a project to study the interaction between photoperiod and temperature.

Over the past year, more than 400 parental lines and 750 advanced lines, including the EP 82, have been evaluated for photoperiod sensitivity. Results from international trials, particularly in the higher latitudes, will be examined against these results to evaluate the importance of photoperiod adaptation in making progeny selections. In the mean time, crosses with photoperiod insensitive lines are being made, particularly in climbing materials, to increase the range of progenies available which incorporate this character. An F_2 population of the cross Rojo 70 x P.I. 310 668 was screened under the lights, and indicated genetic control of photoperiod insensitivity by two major genes. Photoperiod insensitive F_3 progenies have been included in the breeding nurseries for additional evaluation and selection for disease resistances, seed characters and yield.

When day neutral parents are broadly available, as in the case with most classes of bush beans, selection of an advanced generation for day-neutrality may be the most efficient approach, given the oligogenic control of this trait. Intermediate levels of sensitivity may produce a yield advantage under certain cropping systems in some areas. When insensitive parents are few or unknown, as among climbing types, early generation screening may be best. Of 350 advanced climbing lines evaluated in the past year, only 14 day-neutral lines were found, and half of them were genetically mixed. Of all the progenies tested (45) which included an insensitive parent about 1/3 were day-neutral. If attention is paid in parental selection, advanced genetic progeny selection is quite feasible.

Warmer growing temperatures tend to accelerate flowering and maturity, while longer daylengths generally delay flowering in sensitive varieties. However, rather than reducing the effect of long days, higher temperatures actually increase the delay in flowering. Thus photoperiod response is a more critical factor in warm locations than cool, and particularly when the summer growing season combines both the longest and warmest days experienced by the crop. A thesis project, in cooperation with Cornell University and ICTA (Guatemala) is attempting to identify varietal differences in adaptation through a three temperature x two photoperiod factorial study involving 60 varieties of diverse growth habit and origin. Flowering responses are being studied under natural (12.35 hrs) and artificially extended (18 hrs) photoperiods at the three locations previously described (12.5, 18, and 23.5°C mean temperatures). This design combines the stable treatment conditions of growth chamber studies with the larger working area and agricultural relevances of field trials. Varieties are being classified separately into distinct temperature and photoperiod response types, and interaction patterns characterized. Eventually, through the study of strategic segregating populations, a genetic basis for breeding for broad and/or specific adaptation can be formulated and an efficient, reliable screening procedure developed.

Screening EP 82 for Photoperiod Response

The lines in the 1982 EP were evaluated for sensitivity to photoperiod in Palmira through paired comparisons of time from sowing to flowering under natural daylength (12.35 hrs) and under daylength extended to 18 hrs with incandescent lamps (Table 1). Photoperiod insensitive lines were identified among all grain types among the bush habit materials, but only two insensitive climbing lines were found (Table 2). Small seeded lines provided the largest proportions of insensitive lines, reflecting the availability of insensitive parent materials and the importance of day-neutral response especially in Mexico, Central America, and Brazil, regions where small seeded beans are important. Few climbing beans were insensitive, largely because the parental lines originated in the equatorial Andes, where photoperiod hardly varies; the two insensitive lines were derived from crosses with a photoperiod insensitive line from Guatemala. About 7% of the lines in the EP were mixed for their photoperiod response. Single plant selections within these lines are being increased to study the effect of photoperiod response on yield.

Table 1. Distribution of photoperiod sensitivity in 1982 EP materials, by grain type and growth habit.

Group	Grain type	Photoperiod response class[a] 1	2	3	4	5	Total number of lines
10000	Small black	15	2	5	8	0	30
20000	Small red	10	3	3	16	1	33
20500	Medium/large red	5	1	2	20	23	51
30000	Small white	7	0	1	2	1	11
30500	Medium/large white	4	1	2	4	1	12
40000	Medium/large Pacific South	7	1	3	5	5	21
40500	Medium/large Mexican	3	0	0	4	10	17
50000	Small/medium Brazil	25	2	9	10	9	55
60000	Black, high altitude	0	0	0	1	4	5
60500	Black, low altitude	0	0	0	0	2	2
70000	Small red, high altitude	0	1	1	3	15	20
70500	Medium/large, high altitude	2	0	0	2	9	13
80000	Med/large colored, high altitude	0	0	0	1	5	6
80500	Med/large colored, low altitude	0	0	1	2	5	8
	Total	78	11	27	78	90	284
	Not classified						20

a. 1 = insensitive; 5 = extremely sensitive.

Table 2. Selected lines from EP 82 representative of the insensitive and intermediate classes of photoperiod reaction.

Grain type and/or region	Photoperiod class[a] 1	2	3
Bush			
Small black	BAC 93	BAC 112	Moruna 80
Small red	BAT 1670	BAT 1489	BAT 1516
Medium/large red	BAT 1297	BAT 1620	A 465
Small white	BAC 125	-	EMP 111
Medium/large white	A 491	A 497	A 492
Medium/large Pacific South	BAT 1425	BAT 1322	BAT 1456
Medium/large Mexican	A 407	-	-
Small/medium Brazil	A 386	Carioca 80	A 321
Climbing			
Red	VRB 81047	VRA 81072	VRA 81027
Light colors	-	-	VCB 81004

a. Photoperiod class on a 1-5 scale, where 1 = insensitive; 2 = slightly sensitive; 3 = moderately sensitive; (classes 4 and 5, corresponding to sensitive types, are not shown).

19805

Increased N_2 Fixation

The microbiologist and plant breeder initiated in 1978 an intermating and selection program designed to improve the bean plant's genetic capacity to fix nitrogen. In 1982 the fifth cycle of recurrent selection and intermating was completed, adding a number of new parents for combination of factors such as grain type, anthracnose resistance, and high yield potential, as well as capacity to fix nitrogen. Two hundred and seventy F_1 progenies resulted from crosses of these new parents with superior lines from earlier cycles. F_1 hybrids are currently being advanced to the F_2 under field conditions in Popayan.

A disappointing correlation between F_2 single plant yield under Palmira glasshouse conditions and the mean yield per plant of the F_3 progenies observed under field conditions at Popayan, suggested a revision of some aspects of project management. As a result, intermating of glasshouse-selected F_1's has been abandoned in favor of using reserve F_3 seed. This also generates larger F_2 populations, which are selected under field conditions at Popayan. Preliminary yield evaluations and disease ratings are made in the F_3 progeny test, and replicated, and acetylene reduction data are obtained in the F_4.

Improved levels of anthracnose resistance were selected among the 17 coded lines originating from the fourth cycle of intermating, and more attractive grain types were obtained.

19806

Variability from Interspecific Hybridization

Selection at CIAT-Popayan

F_2 generations from different interspecific crosses between Phaseolus vulgaris L. and P. coccineus subsp. coccineus and polyanthus, were planted for individual plant selection. These crosses were made to improve the resistance of P. vulgaris or to include new sources of resistance to the foliar diseases such as anthracnose and ascochyta that prevail in cool climates. Because of the heterogenicity of the P. coccineus parent and consequently that of the F_1 generation, each F_1 plant was harvested separately and considered as an individual entry. The F_2 nursery included 10 different parental combinations.

Eight percent of the plants were selected for their good sanitary aspect and other interesting characteristics such as long racemes and erect stems were observed (Table 1). Previous results from the F_1 nursery coupled with observations in the F_2 show that the best results were obtained by the combination of bush bean lines BAT 338, 788, and 456 with Guate 909 and Piloy (both are P. coccineus subsp. polyanthus).

Selection at ICA La Selva

Four F_2 populations were planted for selection of multiple disease resistant hybrids (Table 2). In general, interspecific crosses appeared to be much healthier than the P. vulgaris planted on the same date and under severe disease pressure of ascochyta leaf spot, anthracnose, oidium and rust. Resistance was observed especially for ascochyta leaf spot and anthracnose, although this disease devastated a P. vulgaris population adjacent to the interspecific field.

Table 2 summarizes the reaction of the interspecific crosses to ascochyta leaf spot, a foliar disease that can seriously affect bean crops in the highlands of Central and South America.

Bumble bee (Xylocopa sp.) and bee (Apis sp.) populations were high and very active in the interspecific trials, especially in the morning. The bumble bees visited far more red flowers (typical of P. coccineus) than white or pink ones. It is very likely that the activity of the bees and bumble bees maintains outcrossing and variability in the interspecific hybrid populations. Selection for the P. vulgaris plant type but with red flowers might provide the means to introduce open pollination into P. vulgaris, for the purpose of recurrent selection.

Table 1. Single plant selection in two different *Phaseolus vulgaris* x *P. coccineus* subsp. *coccineus* population.

Parent identification	n^r seeds sown	% plants selected	Number of plants selected					No. seeds harvested
			Sanitary criteria[a]				Production criteria[a]	
			S.	S.P.	S.C.	S. Lgr.	Lgr.	
BAT 450 x Patzun 1	20	30	3	1		1	1	4
Cargamanto x 88-1	70	2.9	2					0
	70	10	6	1				151
Total	160	9.4	11	2		1	1	

a. S = sanitary aspect; P = precocity; C = pod load; A = erect stem; Lgr. = long raceme.

Table 2. Single plant selection in eight different *P. vulgaris* x *P. coccineus* subsp. *polyanthus* populations.

Parent identification	n[r] seeds sown	% plants selected	Number of plants selected: Sanitary criteria[a]						Production criteria[a]			No. seeds harvested
			S.	S.P.	S.C.	S.Lgr.	S.A.	S.P.C.	C. Lgr.	P. Lgr.	P.C. Lgr.	
BAT 338 x Guate 909	20	20	1		1			1	1			1125
BAT 788 x Guate 909	10	30		1			1			1		863
BAT 788 x Guate 909	50	30	2	7		2		2		1	1	2242
BAT 788 x Guate 909	30	6.7		2								166
BAT 788 x Guate 909	20	25	2	3								415
BAT 450 x Piloy	90	11		1				9[b]				2064
BAT 450 x Piloy	100	3						3				229
BAT 450 x Piloy	80	5	4									55
P 566 x Piloy	10	1		1								285
P 566 x Piloy	20	5	1									28
P 566 x Piloy	70	2.9		2								135
P 566 x Piloy	40	2.5	1									69
P 566 x Piloy	60	5	2	1								194
P 566 x Piloy	100	6	2	3				1				210
Ecuador 299 x Guate 909[c]	70	1.4	1									0
Ecuador 299 x Piloy	70	11.4	3	2				1	1	1	1	524
Ecuador 299 x Piloy	60	11.7	4	1		2						132
Riñón x Piloy[d]	10	1				1						5
Riñón x Piloy	10	3		1				2				135

(Continued)

Table 2. (Continued)

Parent identification	n[r] seeds sown	% plants selected	Number of plants selected: Sanitary criteria[a] S.	S.P.	S.C.	S.Lgr.	S.A.	S.P.C.	Production criteria[a] C. Lgr.	P. Lgr.	P.C. Lgr.	No. seeds harvested
San Martín x Piloy	60	5						3				303
San Martín x Piloy	40	10		1				3				297
San Martín x Piloy	70	0										0
San Martín x Piloy	100	10	1	6				3				630
San Martín x Piloy	70	12.9	4	4				1				407
San Martín x Piloy	100	7	3	2				2				851
Guate 1240 x Piloy	20	15	3									0
Guate 1240 x Piloy	30	6.7	1	1								0
Guate 1008 x Piloy	10	20	2									166
Guate 1008 x Piloy	60	5	1	1				1				393
Total for all entries and selections	1560[e]		38	40	1	5	1	31	1	1		

a. S = sanitary aspect; P = precocity; C = pod load; A = erect stem; Lgr. = long raceme.
b. One plant presenting additionally long racemes.
c. Two entries did not produce any acceptable combination of parental characters for selection.
d. Four entries did not produce any acceptable combination of parental characters for selection.
e. Including entries that did not produce any selection.

9807

Nutritional and Quality Factors

Although the number one priority of the Bean Program is to obtain high and stable yields, improved varieties must also have at least the same level of nutritional factors as their traditional cultivars. Nutritional factors can be broadly classified as those factors influencing the consumption and acceptability of a food, and factors present in a food which determine its chemical and biological value.

The main objective of the food quality and nutritional laboratory is to evaluate whether improved varieties have a good chance of being accepted by the consumer in the target area. Activities in the laboratory during 1982 have focused on the analysis of prior years EP data and the evaluation of the test methodology used in the annual screening of improved varieties. Research was also initiated to investigate color and quality stability over harvest, location, and storage.

EP Screening Procedure

The screening of nutritional factors is integrated into the Bean Program's overall evaluation scheme at the preliminary trial (EP) stage, evaluating annually approximately 300 entries. The procedure summarized in Figure 1 will be followed in the analysis of the 1982 EP and is in accordance with the IDRC Legume Nutritional Standards (Hulse, J. H.; Rachie, K. O.; and L. W. Billingsley).

Equilibration of Seed Moisture Content

Because of observations in the 1979, 1980, and 1981 EP data, it was determined that all seed moisture contents should be equilibrated. A strong, negative correlation has been observed between cooking time and percent water absorption over the last three years (Table 1).

In the 1979, 1980, and 1981 EP screening, one sample of each EP entry was evaluated for nutritional factors. The seed characteristics were evaluated, and the seed was analyzed for protein, moisutre, percent water absorption, cooking time, and broth thickness. Results were expressed in a general sense across all the EP entries. Beginning with the 1982 EP, 100 seeds of freshly harvested improved lines, and 100 seeds of a freshly harvested traditional cultivar within each seed group will be evaluated over two harvest dates grown in Palmira. The seed will be stored in an incubator for a period of 10-30 days to equilibrate seed moisture content. Then, as in previous years, seed characteristics, and the same nutritional factors will be evaluated. The test methodology has been changed for evaluating percent water absorption and cooking time. All data will be evaluated in a comparative sense to the traditional cultivar within each seed group.

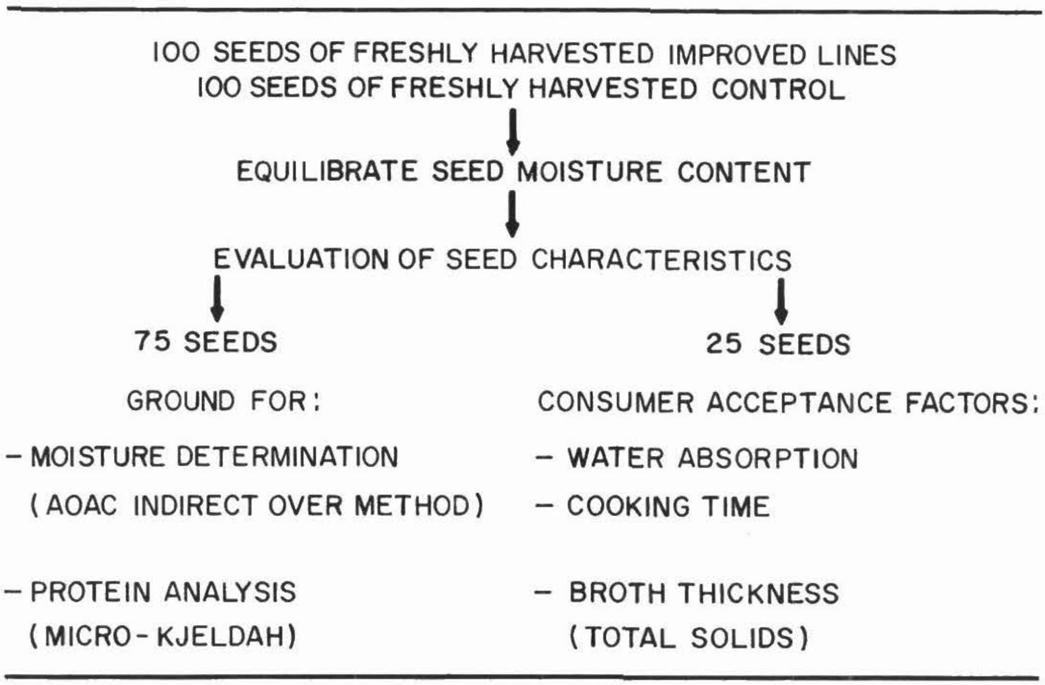


Figure 1. Overview of the routine screening procedure for EP entries.

Table 1. Correlation of cooking time with water absorption.

Year	r of value
1979	- .76 **
1980	- .40 **
1981	- .77 **

** $p \geq .01$.

This correlation in our data could be explained due to either the presence of hardshell or our test methodology used to determine water absorption and cooking time. Hardshell is a reversible type of seed dormancy associated with low seed moisture content and may occur in either fresh or stored seed. Seeds with hardshell have markedly reduced water imbibition and increased cooking time. Mean cooking time and percent water absorption was substantially different in 1981 compared to 1979 and 1980 (Table 2). It is quite possible that the seed analyzed in 1981 contained a lot of hardsehll. Equilibrating seed moisture content will eliminate any effect of hardshell.

Table 2. Cooking time and percent water absorption over 1979, 1980, and 1981 EP entries.

Factor	Year	Mean	Standard deviation
Cooking time minutes	1979	33.64	8.30
	1980	35.45	6.89
	1981	65.74	18.86
% water absorption	1979	70.84	15.87
	1980	60.07	27.49
	1981	47.30	28.66

Consumer Acceptance Factors

Consumer acceptance factors are not well established and vary throughout Latin America. A continual reassessment of important quality factors and evaluation of their regional importance is necessary to properly evaluate improved varieties and laboratory methodology. The consumer acceptance factors considered in the screening program are seed size, color, brilliance, shape, condition, percent water absorption, cooking time, and broth thickness.

The 1980 and 1981 EP entries indicated that nutritional factors were significantly different among regionally preferred seed groups (Table 3). The negative correlation between percent water absorption and cooking time was observed again with small, determinate whites having significantly greater water absorption and shorter cooking times than light color, indeterminate beans. Growth habit tended to influence both broth thickness and protein content. Determinates, regardless of seed type, tended to have thicker broths than indeterminates. In 1980, determinates had higher percent protein content, but in 1981 indeterminates were higher.

Percent water absorption. Water absorption was previously determined by soaking the beans for four hours in a 2% NaCl, $NaHCO_3$ solution. Since this is not a standard method and does not reflect traditional preparation methods, water absorption will be determined by soaking the seeds for eight hours in deionized water at room temperature.

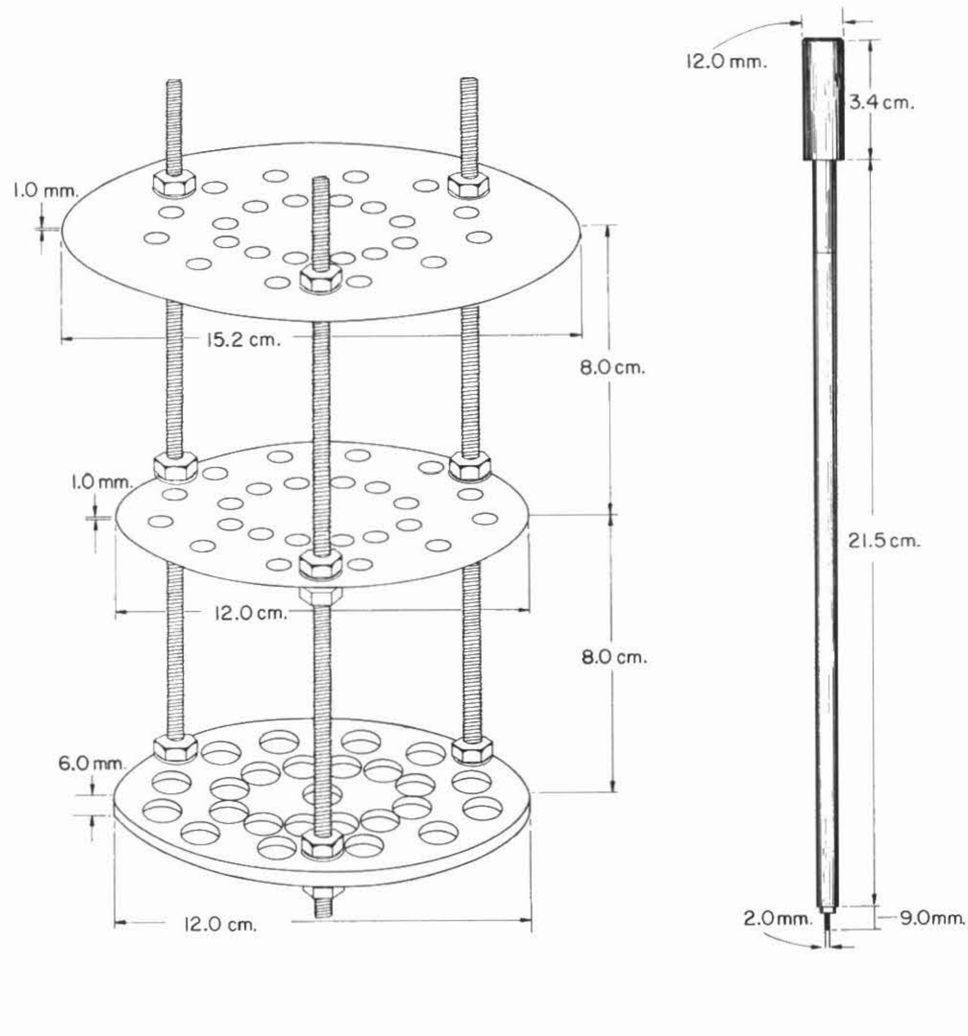
Cooking time. Cooking time of beans has been observed to proceed along a sigmoidal time course with very little variation (Jackson, M.G. and Varriano-Marston, E.). Until this year cooking time was determined by squeezing a bean between the thumb and forefinger at periodic time intervals, and subjectively evaluating the bean's resistance. This technique is inadequate due to not only possible sampling error, but especially its subjectivity. In search of a more objective and accurate measurement, a modified-mattson cooker modelled after Michael Jackson at Kansas State has been constructed (Figure 2).

Table 3. Difference in nutritional factors between seed groups by region in 1980 and 1981 EP entries.

	Nutritional factor	Year	F value
Seed group by region	% water absorption	1980	1.03 NS[a]
		1981	3.23 **
	Cooking time	1980	3.81 **
		1981	4.21 **
	Broth thickness	1980	3.82 **
		1981	2.10 **
	% protein content	1980	5.12 **
		1981	2.30 **

a. NS = nonsignificant.

** $p \geq .01$.



To determine cooking time, the beans are placed in each of the 25 depressions in the bottom plate of the cooker so that the piercing tip of each 89 gram rod is in contact with the surface of the bean. The cooker is then lowered into boiling water inside a 2 liter glass beaker. A cooked condition is measured when the tip of the bar perforates the bean. The cooking rate for four replications of one variety using the experimental cooker is shown in Figure 3. The coefficient of variation for the four replications was 8%.

Chemical and Biological Value

The only factor influencing chemical and biological value being routinely evaluated is percent protein content. Protein content in Phaseolus vulgaris has been found to vary between 17 to 35%. Cooked P. vulgaris has the poorest digestibilities of all the legume species. Its protein digestibility determined by rat feeding trials is between 69 to 74%. If rapid screening tests become available in the future we will screen all our new lines for sulfur amino acid content and digestibility to make sure improved lines have the same or better protein quality as their traditional cultivar.

Correlations between protein content and yield ranged from 0 to -.21 (Table 4). The failure of this correlation to be consistent over year and location indicates that an important environmental interaction exists. This low correlation indicates it may be possible to select for high yield and high protein content.

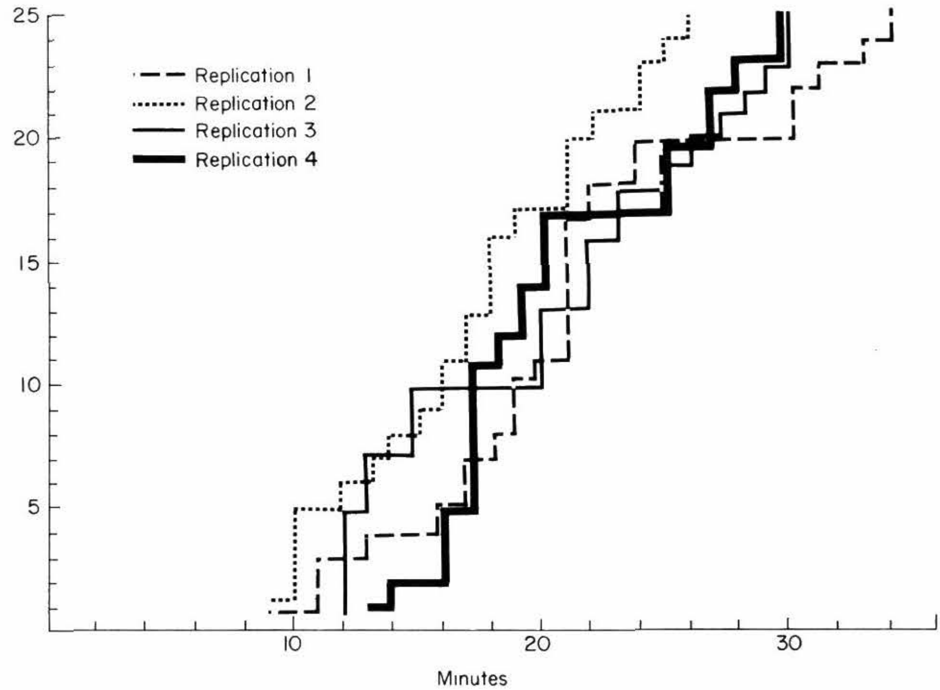


Figure 3. Cooking rate over four replications for one variety using the experimental cooker.

Table 4. Correlations of protein content with yield.

Year	Location	r value
1979	Palmira	-0.00 NS
	Popayan	- .21 **
	Average yield of both locations	- .16 *
1980	Palmira	.04 NS
	Popayan	- .16 NS
	Average yield of both locations	.05 NS
1981	Palmira	- .21 **
	Popayan	- .13 NS
	Average yield of both locations	- .20 **

* $p \geq .05$
** $p \geq .01$

Research Activities

Color and cooking quality have been observed to vary within a variety over harvest date, location, and storage. It has been observed that some traditional varieties maintain good color stability under adverse conditions, whereas some breeding lines tend to be very variable. For this reason, we are evaluating color and quality stability of breeding lines and commercial cultivars grown over two harvest dates in Popayan and Palmira. Color evaluation will be made by comparing seed color to Munsell color charts.

References

Hulse, J. H., Rachie, K. O., and L. W. Billingsley. Nutritional Standards and Methods of Evaluation for Food Legume Breeders. IDRC. Ottawa, Canada, 1977.

Jackson, M. G. and E. Varriano-Marston. Hard to Cook Phenomenon in Beans: Effects of Accelerated Storage on H_2O Absorption and Cooking Time. Journal of Food Science, 1981.

7808

Cultivar Improvement

The number of crosses made in 1981 for cultivar improvement are listed in Table 1.

Genetic Improvement for Central America, Coastal Mexico, and Peru, and the Black Grain Types

Small red and small black grain types for Central America

The evolution of bean breeding activities in Central America, and especially with the regional outreach program represents an interesting study of technology transfer (at the research level) and increasing self-sufficiency in research at the national program level. Until 1977, no small-seeded red materials resistant to BCMV were available for testing and use in crosses, which greatly slowed breeding work for all other objectives. The recovery of BCMV resistant reds opened new opportunities to move ahead rapidly, especially for *Empoasca*, CBB, and BGMV resistance breeding. Similarly, not a single red-seeded germplasm accession merited inclusion in the first IBYAN's. Almost all screening and selection was performed in Palmira, especially where diseases like BCMV and CBB were artificially inoculated.

As the genetic quality of red breeding lines improved, and as well-trained national program scientists became more involved in screening and selection activities, emphasis in evaluation and selection of populations, early generation families, and advanced lines has shifted away from Palmira towards Central America and the national programs (Table 2). Evaluations such as BCMV, CBB, and *Empoasca* can still be most efficiently performed at CIAT, but testing for BGMV, Mustia, *Apion*, rust races, and adaptation to the relay cropping system, are all best conducted at the national program level.

Several factors contributed to the rapid shift: a) development and utilization as parents, of multiple disease and insect resistant lines, greatly increased the frequency of segregants of interest to national programs; b) the enthusiasm and technical capabilities of ex-trainees to work with improved materials at the national program level; c) active participation of regionally outposted staff in the national programs to catalyze the process; and d) recognition of the fact that components of local adaptation must be selected by each national program. In particular, workshops at the regional level pointed out how diverse local growing conditions really are in Central America and suggested that CIAT reshape its delivery system to accommodate this fact.

As has been shown in earlier sections, work in the BGMV, Mustia, and *Apion* projects has been largely at the national program level since its initiation. Some F_2 and F_3 populations for multiple factor crosses were taken to Costa Rica and Nicaragua, as early as 1979 and selections from those crosses are currently being tested as varieties and advanced

Table 1. Responsibilities for character and cultivar improvement project of the three breeders of the Bean Program.

Research area	Responsible breeding program			No. of crosses made	
Character improvement					
Bean common mosaic virus	I[a]			127	
Bean golden mosaic virus	I			221	
Rust	I			21	
Common bacterial blight	I			101	
Halo blight			III	2	
Web blight	I			12	
Anthracnose		II		36	
Angular leaf spot		II		21	
Ascochyta leaf spot			III	76	
Mildew			III		
Bean scab			III		
Empoasca leafhoppers	I			183	
Apion pod weevil	I			29	
Storage insects			III	28	
Beanfly			III		
Mexican bean beetle		II		17	
Nematodes			III		
Drought		II		34	
Low temperature			III		
Low P		II		20	
Maturity		II		20	
N_2 fixation	I				
Architecture		II		21	
Snap beans			III	56	
				1025	
National cultivar improvement					
Black beans	I			121	
Central America	I			105	
Caribbean	I			40	
Coastal Mexico, Peru	I			186	
Other studies	I			307	
Brazil (non-black)		II		70	
Mexican highlands		II		162	
Argentina		II		119	
Andean Zone			III	274	
Africa			III	308	
				1692	2717

a. Breeding program: I = S. Temple; II = S. Singh; III = J. Davis.

Table 2. Adaptation nurseries planted in Central America.

Season	Number	Color	Location	Factors evaluated
1981A	270	Red	Honduras	Grain type, adaptation
	281	Red	El Salvador	Nematodes, BGMV, mites, grain type
	246	Red	Nicaragua	Grain color and size, adaptation
	30	Red	Costa Rica	Grain type, rust, (mustia, excess water)
1982A	175	Red	Honduras	Grain quality, maturity
			El Salvador	Rust, yield, flowering, maturity
	46	Red	Nicaragua	Grain type, adaptation (excess water)
1982B	50	Red	Nicaragua	(From best 1982A in El Salvador)
	229	Red	Honduras	
			Costa Rica	Rust, als, maturity
			El Salvador	BGMV, relay with maize
1982B	84	Black	Costa Rica Guatemala	Rust, als

lines. In 1981 the first nursery of advanced and early generation lines (uncoded and pre-VEF) was planted in El Salvador (281 entries), Nicaragua (246), Costa Rica (30), and Honduras (270). This adaptation nursery was neither uniform nor replicated, but observations assisted in the choice of advanced lines for coding and submission to the VEF, as well as to identify the best-adapted materials for use in the crossing program. As a result of this nursery, Honduran scientists have identified two superior lines that are currently in regional yield trials, El Salvador selected lines resistant to severe nematode attack and with good adaptation, and Nicaragua, after three seasons of testing, has identified several promising good lines.

In 1982, groups of early generation families and advanced (parental) lines were distributed in Central America in both the first and the second semesters. Two hundred and fifty red materials were tested in single row observation plots in Honduras and El Salvador, and 84 black-seeded lines from the crossing block were planted in Guatemala and Costa Rica, in 1982A. Non-replicated, 10 plant yield samples were taken for red lines in El Salvador, and for black lines in Guatemala. Valuable data was also obtained for field response to CBB, BGMV, and root rots (for the black nursery), and for rust, grain type, grain quality, maturity, and response to excess moisture in the red-seeded nurseries.

From the 1982A nurseries, the following conclusions were drawn:

- More emphasis is now placed on earliness for both red and black-seed selections for Central America.

- For red progenies, acceptable tones are emerging from persistent intermating and backcrossing, but more care must be given to colors that do not "wash out" and to larger grain size.

- The adaptation of progenies selected in Colombia to Central American growing conditions, is much better than that of Central American commercial varieties evaluated in Colombia. This fact is most apparent among red genotypes, and remains unexplained.

- The identification and use of appropriate check varieties at regular intervals facilitated the evaluation of the nurseries, especially for the small yield sample.

- Few entries were immune to rust, but few materials were highly susceptible. Lines with known levels of resistance to CBB retained that reaction under field conditions.

- Valuable information was obtained on parental combinations to be used in future crosses. The best 50 selections were identified for testing in Nicaragua in 1982B.

- There is great interest in and need for testing this type of introduction nursery in the second semester, and especially in the relay system with maize.

A number of progenies appear to express guide development useful for the relay cropping system, while others demonstrate growth habit and branching patterns valuable to minimize weed control problems. The relationship of plant growth habit and guide development between Colombia and Central America is being evaluated more intensively. An additional important observation was made upon the importance of determining "percent saleable seed". Regardless of whether the farmer sells his crop for purpose of replanting (seed multiplication) or for domestic consumption, he is concerned about the cost of hand-selecting the harvested seed to eliminate those which are small, rotten, or washed out in tone. Environmental conditions prior to harvest frequency lead to sizeable losses to these problems in Central America, so that more attention is being placed on genetic response to such factors.

In the 1982B semester, 229 red lines were planted in Costa Rica and Honduras, and 84 black lines were planted in Costa Rica and Guatemala. Preference was given to progenies with soft red tones, which is the most preferred grain type.

Most significant among results of the 1981 VEF-1982 EP evaluations and from testing the red crossing block in Honduras and El Salvador in the 1982A season, is the fact that several red lines combining multiple factor resistance were well adapted in Palmira and Popayan. The same lines demonstrated excellent adaptation and commercially acceptable grain quality under growing conditions in Central America (Table 3). Thus we have combined the rusticity of noncommercial BAT 93 with the adaptation of BAT 41 and A 40 and the grain color of locally-grown commercial cultivars.

Table 3. Multiple resistant red genotypes with commercial grain quality and excellent adaptation in the Central American adaptation nursery, 1982A.

Identity	PGH	Maturity	Rust	Xanthomonas	ALS	Ascochyta	Anthracnose	Notes
BAT 1336	3	Medium	2	3.0	4.5	2.5	3.5	Excellent grain quality
BAT 1500	3	Medium	5	2.5	2.5	3.0	1.5	
BAT 1514	2A	Medium	2	3.0	2.5	2.7	2.5	Very erect growth habit
BAT 1631	2	Early	3	3.0	2.0	3.0	4.5	
EMP 105	2	Medium	4	5.0	1.5	2.2	4.0	_Empoasca_ resistance
Elite controls								
BAT 93	3A	Medium	2	2.5	2	3	1.0	Cream grain (non-commercial)
BAT 41	2	Early	2	4.0	2	3.0	5	Dark red opaque, early
A 40	3A	Early	5	4.0	5	3.0	5	Dark grain

New crosses and selections of Central American grain types were made in CIAT nurseries. Ninety-nine crosses of interest to specific Central American countries were made, while 102 multiple factor hybrids of general interest for the region were generated. An extensive group of red and black seeded commercial cultivars are being evaluated repeatedly in the crossing block, the early generation adaptation nursery (locally and regionally), and as check varieties in the routine evaluation for rust, CBB, anthracnose, and general adaptation.

Genetic Improvement of Red and Red Mottled Grain Types for Caribbean Countries

Breeding efforts for the region have focused upon the recombination of resistance to BCMV, BGMV, CBB, and *Empoasca*, in high yielding genotypes of the preferred grain types (medium sized red mottled). Progress for several years was slowed by adverse character association of BCMV susceptibility with the soft red mottled tones. This difficulty appears to be resolved, and breeding work is advancing more rapidly on all the above traits. An early-generation adaptation nursery containing 187 lines was evaluated in the Dominican Republic in 1981-1982, and several materials are being tested more extensively. A set of 362 lines from more recent crosses and parents from the mottled crossing block were sent to Haiti, Jamaica, and the Dominican Republic in 1982. Some indeterminate progenies with attractive grain colors have been obtained. Seed size must still be increased.

A total of 31 new mottled lines were coded, and 40 new crosses were made. Additionally, many of the specific character or project crosses for BCMV, BGMV, and *Empoasca* continue to emphasize mottled grain types. A detailed proposal for introduction and evaluation of germplasm was developed in collaboration with Dominican bean scientists and other international assistance programs active in the country.

Genetic Improvement of Grain Types Commercial in the Pacific Coasts of Peru and Mexico

These two production regions, so widely separated geographically, have much in common with respect to preferred grain types, production systems, ecological conditions, and production-limiting factors. The soft yellow and cream tones of the Canario and Bayo classes have been difficult to recombine with dominant resistance to BCMV. A large number of progenies with tones slightly different than those commercially-preferred types are being retested for BCMV reaction. Grain size is still inadequate.

As in the Caribbean mottled class, progress in reselecting resistance to *Empoasca*, BGMV, and rust among Canarios has been limited by the association of preferred grain types with BCMV susceptibility. Additional crosses have been made to incorporate resistance from the multiple recessive gene series.

The second factor which has impeded progress in the Canario and Bayo grain types is the relatively narrow range of physiological adaptation expressed by commercial cultivars. No CIAT research station in Colombia has been identified in which Canario grain type and plant type are faithfully expressed, even when large quantities of pesticides are used to counteract their susceptibility to BCMV, CBB, Empoasca, anthracnose, and ascochyta. As a result, progenies must be evaluated by the national program as soon as reselection for BCMV and Empoasca have been realized in Colombia, and little or no selection pressure may be applied in Colombia for traits such as yield and plant architecture.

For Canario and Bayo colors, a total of 56 and 130 crosses were made for Mexican and Peruvian types, respectively. The Peru crosses include a limited number for the small white ("navy" bean) class, which is grown as a summer crop in parts of the coast, and to a lesser extent in the lower mountain valleys. Twenty-five white and 91 Canario and Bayo lines were coded in 1982.

In Peru an active introduction and testing program was initiated between CIAT and INIPA in 1981, through the specially-funded outreach activity. In the 1982A semester a total of 690 materials were evaluated in different nurseries in Coastal Peru, and in 1982B, 553 materials were planted. Bean production conditions in Peru vary with planting season and location. As a result, germplasm from several programs and covering a wide range of adaptation and characters was introduced. Germplasm delivered to Peru for evaluation in 1982 included introductions from the United States, populations and early generation families from crosses to IVT recessive to BCMV, and hybrid and germplasm bank sources of resistance to rust and Empoasca.

Following trips to Peru in 1981 and 1982 to evaluate the large number of introduced materials, it appears that careful choice of planting date and location will permit increased local activity in the selection for resistance to BCMV and root rot pathogens. This is significant because of the adaptation problem discussed above. A comprehensive plan for the introduction and evaluation of germplasm was developed with INIPA scientists.

Genetic Improvement of Materials for Cuba and Panama

Cuban varieties are comparable to Central American and Mexican Gulf Coast black opaques in grain type and adaptation, and most of the same factors are of highest priority (e.g., BGMV, CBB, rust). Thus most of Cuba's needs are satisfied by selections from the IBGMVN and advanced lines from the EP-IBYAN scheme.

Web blight is the most important limiting factor for bean production in Panama, but plant growth habit and grain types are more similar to Caribbean varieties than to Central American types. Until better donors of web blight resistance are available, evaluation of progenies from the web blight program and advanced kidney and mottled grain types from the EP and IBYAN nurseries will be used.

Genetic Improvement of Materials for Chile

The Chilean national program and commercial companies have successfully introduced navy bean germplasm from the United States into commercial production. Most of the important commercial varieties in other grain types are locally well adapted genotypes from previous breeding efforts. The national program requested and received from CIAT In 1982 a total of 904 materials, including F_2 populations, F_3-F_5 families, and advanced, coded lines from CIAT, the germplasm bank, and from other breeding programs.

Principal objectives for increasing bean production in Chile include resistance to bean yellow mosaic virus (BYMV), resistance to necrosis-inducing strains of BCMV, and improved plant architecture and yield. Most of the introduced material carries genes for one or more of these factors. All hybrid materials must be selected locally beginning with the F_2, especially since there is such a poor correlation between yields in Colombia and yields in Chile.

19809

Genetic Improvement for Brazil, Mexico, and Argentina

Brazil (non-blacks)

Among the non-black beans, cream (Mulatinho and Bico de Oro), pink (Roxo and Rosinha), brown (Pardo or Chumbinho), and beige (Baio and Enxofre), listed here in an approximate order of importance, have traditionally been the principal grain types. Within the last 10 years or so, however, the variety Carioca of cream striped grain type became very popular all over Brazil due to its relatively higher and stable yield. In certain areas, Jalo (similar to Mexican Canarios), Gordo (similar to Ecuadorian and Peruvian Bayos), and Chita Fina or Cavalo Claro (medium and large cream mottled), are grown on small scale. Genetic improvement of these latter commercial types will not be undertaken, instead, experimental lines of similar grain types will be introduced when encountered in improvement programs.

The breeding at CIAT of Mulatinho and Pardo began in 1976, Carioca in 1978, Roxo and Rosinha in 1980, and of Enxofre only this year. Table 1 indicates responsibilities for the project and Tables 2 and 3 indicate the major production regions of Brazil where non-black beans are grown and their production limiting factors. A summary of experimental lines developed, thus far, is given in Table 4. A few of these lines were introduced in Brazil through the IBYAN in previous years, but the majority were sent in special nurseries in the later part of 1981 and early 1982. As a result, their true agronomic potential in Brazil is not yet known. However, in Table 5, some characteristics under CIAT conditions of few promising lines of Mulatinho grain types are given. The traditional commercial varieties, e.g., Mulatinho Vagem Roxa, Favinha, and Rim de Porco, are not included in the Table, due to their high susceptibility to BCMV, CBB, rust, anthracnose, and angular leaf spot; and subsequently very little or zero yield. In comparison to these, the yield of new experimental lines bred in Brazil or CIAT seems to have increased by 3 to 4 folds. Also, over a dozen CIAT lines outyielded the best lines bred in Brazil. While all CIAT bred lines carry resistance to BCMV, a great majority of them also exhibit resistant or intermediate reaction to anthracnose. The third cycle of hybridization and selection for Mulatinho was initiated this year with major emphasis to combine resistance to CBB and angular leaf spot with that of BCMV and anthracnose. The breeding work and progress for Carioca and Pardo grain types is following similar patterns.

The breeding nursery for drought tolerance was sent to Dr. Paulo Miranda of IPA, Pernambuco, who had received a similar but smaller nursery in 1980. This year's nursery included 144 experimental lines of Mulatinho grain types, 77 germplasm bank accessions, 44 sources of tolerance to drought and other production limiting factors, and 51 segregating hybrid populations. Drought, root rots and the attack of angular leaf spot in the nursery were very severe. The Brazilian pathogen populations of Isariopsis overcame the resistance of all but G 2335 and G 5653. This and the absence of BGMV in Colombia and the fact that the Brazilian populations of anthracnose pathogen in the past have broken down the resistance of several lines identified in Colombia, further emphasize the need for early generation screening and selection within Brazil. The increasing collaboration between CNPAF (National Centre for Rice and Bean Research) and CIAT is instrumental.

Table 1. Responsibilities for character and cultivar improvement project of the three breeders of the Bean Program.

Research area	Responsible breeding program			No. of crosses made	
Character improvement					
Bean common mosaic virus	I[a]			127	
Bean golden mosaic virus	I			221	
Rust	I			21	
Common bacterial blight	I			101	
Halo blight			III	2	
Web blight	I			12	
Anthracnose		II		36	
Angular leaf spot		II		21	
Ascochyta leaf spot			III	76	
Mildew			III		
Bean scab			III		
Empoasca leafhoppers	I			183	
Apion pod weevil	I			29	
Storage insects			III	28	
Beanfly			III		
Mexican bean beetle		II		17	
Nematodes			III		
Drought		II		34	
Low temperature			III		
Low P		II		20	
Maturity		II		20	
N_2 fixation	I				
Architecture		II		21	
Snap beans			III	56	
				1025	
National cultivar improvement					
Black beans	I			121	
Central America	I			105	
Caribbean	I			40	
Coastal Mexico, Peru	I			186	
Other studies	I			307	
Brazil (non-black)		II		70	
Mexican highlands		II		162	
Argentina		II		119	
Andean Zone			III	274	
Africa			III	308	
				1692	2717

a. Breeding program: I = S. Temple; II = S. Singh; III = J. Davis.

Table 2. Bean production regions of Brazil (1978-79).

Region	States	Area (ha)[a]	Production[a]
1. South	RS, SC, PR	1.156,356	831,971
2. South-east	MG, SP, RJ, ES	940,044	513,352
3. Central-west	GO, MTS, MIN	276,141	127,325
4. North-east	BA, PE, SE, AL, PB, RN, PI, CE	1.792,829	683,083
5. North	AC, AM, AP, PA, RO, PR	0,491	27,443
	Total	4.205,861	2.184,940

a. 5-10% cowpea
25% black beans

Table 3. Production regions of non-black beans in Brazil, commercial varieties and their problems.

Region	Grain type	Varieties	Year[a]	Problems
South-east and Central-west	Cream	Mulatinho Paulista	1976	BGMV, common bacterial blight, anthracnose, angular leaf spot, leafhoppers, rust, low soil phosphorus
	Cream striped	Carioca	1978	
	Pink	Rosinha	1980	
	Purple	Roxao	1980	
	Brown	Aroana	1976	
	Beige	Rico Baio	1982	
North-east	Cream	Mulatinho Vagem Roxa, Favinha Rim de Porco; IPA 74-19	1976	Drought, root rots, Leafhoppers, Angular leaf spot, rust, anthracnose, common bacterial blight

a. The year breeding was initiated at CIAT.
Cropping season: February-May, October-January, April-August
Cropping system: Monoculture and intercropping
Institutions dedicated to bean improvement: CNPAF, EPAMIG/UFV, IAC, IAPAR, IPA.

Hybridization and selection of Roxo and Rosinha varieties received maximum attention this year. All crosses made in the latter part of 1981, were quickly advanced to the F_2 for evaluation and selection. Several hundred of the F_3 and F_4 families are being progeny tested simultaneously at CIAT-Palmira, Quilichao and Popayan farms.

Table 4. Number of experimental lines of non-black Brazilian bean types developed in CIAT.

Grain type	Year 1978	1979	1980	1981	Total
Mulatinho	11	6	28	107	152
Pardo	28	17	4	29	78
Carioca	-	-	12	48	60
Total	39	23	44	184	290

Table 5. Reaction to diseases and Empoasca, and grain yield (kg/ha) of some experimental lines of Mulatinho grain types, as compared to some Brazilian improved lines evaluated at CIAT.

Identification	Growth habit	BCMV	Anthracnose	Angular leaf spot	Rust	CBB	EMP	Yield[a] (CIAT 1982B)
1. A 305	IIIa	R	R	S	S	S	S	2121
2. A 140	III	R	R	I	S	I	-	2008
3. A 360	I	R	R	S	S	S	-	1992
4. A 319	III	R	R	S	S	S	-	1889
5. A 359	IIa	R	R	I	I	S	I	1857
6. BAT 336	IIa	R	I	S	I	S	S	1807
7. A 161	IIb	R	I	S	S	S	-	1769
8. A 354	II	R	I	R	S	S	I	1765
9. A 101	IIb	R	S	S	S	S	S	1758
10. A 162	IIIa	R	I	S	S	I	-	1741
Mean								1870
Brazilian improved varieties								
AETE 1/37	III	R	S	S	S	I	-	1600
CATU	II	R	R	I	S	I	-	1536
AETE 3	II	R	I	S	S	I	-	1298
Mean								1478

a. Grown under moderate moisture stress.

Mexican Highlands

Bean production in the highlands of Mexico is characterized by scarce and erratic rainfall. Usually the frost-free effective growing season is less than 150 days. Some useful information related to bean production characteristics of the region are summarized in Table 6. As a priority, early maturing (bush and climbing beans of 85 and 120 days, respectively) and stable yielding varieties resistant to principal production limiting factors are being sought for cultivation in temporal conditions. Erect and upright type I and II varieties of Flor de Mayo will be developed for irrigated system.

The first few crosses for the genetic improvement of Flor de Mayo, Pinto and Ojo de Cabra grain types were initiated at CIAT in October of 1978. However, our trip to Mexico in September of 1980 clarified the importance of the Bayo and pink varieties, in addition to that of Flor de Mayo, Pinto, and Ojo de Cabra types, their limiting factors, research needs, etc. As a result, intensive and more directed breeding efforts could be undertaken.

Table 6. Bean production regions of Mexican highlands, varieties and problems.

Production region	Varieties	Problems	Year[a]
1. Semi-arid (850,000 ha) Zacatecas Durango Chihuahua SLP, Aguas Calientes Hidalgo	Bayo Rio Grande Pinto Fresnillo Delicias 71 Ojo de Cabra 400	Drought, *Epilachna* *Apion* Anthracnose, angular leaf spot, common bacterial blight, rust, *Empoasca*	1980
2. Humid (400,000 ha) Jalisco Michoacan Guanajuato Puebla	Garbancillo Zarco Flor de Mayo Rosa de Castilla Cejita	Anthracnose, angular leaf spot, common bacterial blight, rust, *Apion*, *Epilachna*, Halo blight	1982
3. Irrigated (75,000 ha) El Bajio	Flor de Mayo	BCMV, rust	1982

a. The year breeding was initiated at CIAT.
National institutions: INIA regional stations of CIAMEC, CIAB, CIANOC, and CIAN.

All commercial varieties and germplasm bank accessions from Mexican highlands evaluated, thus far, have been found highly susceptible to the bean common mosaic virus. Most seem to be rather poorly adapted to Colombian conditions. In the initial cycle of hybridization, therefore, greater emphasis is being given to the incorporation of resistance to BCMV. Experimental lines bred for Brazil, which although are relatively smaller in seed size but possess similar growth habit and grain color and are better adapted, are being used as donor parents for transferring resistance to BCMV, common bacterial blight, drought, etc. This, nonetheless, sometimes poses problems for the recovery of certain grain colors, e.g., Flor de Mayo and Pink, and to some extent, size of the seed. A large proportion of new genetic recombinants are of non-commercial grain types which have to be selected out. Top-, back-, three-way- and modified double-crosses are being increasingly utilized to increase the frequency of desirable segregates. Table 7 indicates the number of experimental lines with resistance to BCMV developed until now. Some of these are deficient in their grain characteristics.

The first breeding nursery from CIAT, comprising the parental crossing block, i.e., 290 germplasm bank accessions including commercial varieties and 44 sources of resistance to the major production limiting factors, 39 segregating hybrid populations and 89 bred lines, was grown at four Mexican highland research stations of INIA: CIAB-CAEJAL, Tepatitlán, CIANOC-CAEZAC, Caleras; CIANOC-CAEVAG, San Francisco I Madero; and CIAN-CAESICH, Sierra de Chihuahua. Two and a half months after planting materials were evaluated at the former three locations for general adaptation, growth habit, response to drought, common bacterial blight, anthracnose, halo blight, etc. Marked and useful differences were observed within each group of materials. Variation in performance across locations were obviously large and only very few materials were good at all sites. Bush bean lines selected primarily at CIAT-Palmira, had in general, stunted growth. The majority of climbing bean accessions from the germplasm bank were sensitive to longer days and either did not flower or failed to climb on maize. Also, the pathogen populations of anthracnose at CIAB-CAEJAL, Tepatitlán, overcame the resistance of some bank accessions and experimental lines identified in Colombia. In spite of these factors, some lines bred at CIAT performed well (Table 8). All information gathered so far will be utilized in the next cycles of hybridization and selection of progenies.

Breeding of semi-climbing and climbing beans for humid highland regions has received increasing attention this year. Climbing bean varieties Garbancillo Zarco, Rosa de Castilla, and Flor de Mayo, have been utilized in over 30 crosses. Also, in order to minimize management cost of the breeding nurseries and to facilitate selection process, segregating F_2 populations of climbing beans were space-planted in monoculture, similar to bush beans. Selections were made for BCMV and common bacterial blight resistance at CIAT-Palmira and anthracnose and angular leaf spot at CIAT-Popayan. Desirable plants with weak stem and branches also possessing long guide were selected for the progeny test and preliminary yield evaluations in the F_3 and F_4 generations, respectively, in association with maize. This selection procedure will be used on a trial basis until its real merits are known at later dates.

Table 7. Number of experimental lines of beans available for Mexican highlands.

Grain type	Year 1980	Year 1981	Total
Bayo	3	1	4
Flor de Mayo	5	10	15
Pinto	12	30	42
Ojo de Cabra	2	26	28
Total	22	67	89

Table 8. Characteristics of some CIAT improved bean lines for Mexican highlands.

Identification (Comm. var./ improved line)	Growth habit	BCMV	Anthracnose	Rust	Common blight	Angular leaf spot	Grain yield (kg/ha) CIAT 1982B
Flor de Mayo	III	S	S	S	S	S	-
A 114	III	R	I[a]	S	S	R	623
A 406	III	R	I	S	S	S	1293
A 409	III	R	I[a]	S[a]	I	S	1397
Bayo Rio Grande	III	S	S	S	S	S	-
A 157	II	R	I	R	S	R	-
A 177	I	R	R	I	S	R	1840
A 410	III	R	R	S	I	S	1299
Pinto Fresnillo	III	S	S	S	S	S	-
A 416	III	R	R[a]	S	S	S	961
A 424	III	R	R	S	S	S	872
A 426	III	R	S	S	S	S	1052
Ojo de Cabra 400	III	-	R[a]	S	S	S	-
A 69	I	R	I	S	S	R	2549
A 440	III	R	R	S	S	R	2308
A 457	II	R	I	S	S	R	2746

a. Reaction in Mexico in 1982 changed from I or R to S and vice versa.

In the future, much greater emphasis will be given for improvement and recovery of Flor de Mayo, Rosa de Castilla, and Bayo varieties. Early generation screening and selection for anthracnose and drought in Mexico will be intensified in close collaboration with INIA. Similar procedures will be followed for incorporation of resistance to Epilachna and Apion, neither of which can be screened for within Colombia.

Argentina

Bean cultivation in Argentina has increased substantially within the last 15 years. Nearly 200,000 ha were planted under beans in 1981. Of this, over 75% of the area was occupied by one traditional variety called Alubia, which is of determinate growth habit type I with large white seeds. The remainder is dedicated to the culture of varieties of black beans, chaucha colorada, etc. Major production regions and problems of Alubia are given in Table 9.

Table 9. Production regions of Alubia beans in Argentina and its problems.

Regions[a]	Problems
Salta Santiago de Estero Tucuman Jujuy	BCMV, chlorotic mottled virus, anthracnose, angular leaf spot, common bacterial blight, web blight, leafhoppers, mechanization

a. Divided into: humid-temperate (25,000 ha), sub-humid temperate and warm (125,000 ha), semiarid (50,000 ha).
Cropping system: Monoculture from January to May.
Institutions: INTA and EEAIOC
Breeding initiated at CIAT in 1979.

For convenience and to facilitate breeding process, the bean production regions of north-west Argentina have been divided into four: humid-temperate, sub-humid temperate, sub-humid warm, and semi-arid. Until now, bean chlorotic mottle virus has not become a problem in the humid-temperate areas. Other production limiting factors are more or less similar, only their order of priority changes from one region to another.

It is worth noting that the large seeded Alubia grain type is probably extensively grown and consumed in some North African, West Asian, and European countries, its cultivation in Latin America at the moment is only restricted to Argentina. Since genetic improvement of Alubia, both in Argentina and at CIAT, only started in 1979-80 crop season, no improved germplasm exists at the moment. Due to all of these facts and the high demand by the National Program scientists for improved Alubia germplasm, up to four crops/year have been taken at CIAT for the improvement of Alubia.

Over 100 crosses of Alubia were made in 1982 in order to transfer desirable genes for resistance to the BCMV, common bacterial blight, anthracnose, angular leaf spot, bean chlorotic mottled virus, and leafhoppers. Also, nearly 2000 individual plant selections from several dozens of F_2 and F_3 populations were progeny tested for agronomic performance, resistance to BCMV, common bacterial blight, anthracnose and angular leaf spot. Relatively uniform and outstanding families will be bulk harvested for preliminary adaptation observation at 4-6 key sites in north-western Argentina in 1983 cropping season.

After having made over 200 crosses over the past years for transferring resistance to different production limiting factors into variety Alubia more emphasis is now being given towards improvement of its plant architecture and yielding ability per se. High and stable yielding varieties of relatively long growing season, 100 days or more, with strong upright stem resistant to lodging are being sought. Unfortunately, like resistance to diseases and insect pests, the desirable architectural traits, at the moment, are all found only in small seeded lines, e.g., A 56, A 57, A 126, A 132, A 156, A 199, A 207, A 208, A 209, etc. Genetic gains from selection in recovering Alubia grain types with desirable traits from these donor parents is expected to be small and gradual. In an attempt to transfer resistance to anthracnose and angular leaf spot from small seeded lines A 140 and BAT 332, respectively, into large white seeded accessions G 13257 and Fabada, the F_1 hybrids G 13257 x A 140 and Fabada x BAT 332 showed hybrid dwarfism and subsequent death. Apparently this phenomenon which has been recorded in over 80 such hybrid combinations so far, was a manifestation of a genetic barrier or incompatibility between the two classes of germplasm. Also, large seeded upright F_3 and F_4 families seem to be more susceptible to stem breakage at post flowering stage.

Similar to 1981, a breeding nursery comprising the crossing block of germplasm bank accessions and sources of resistance, segregating hybrid populations, bulks of early generation families, and experimental lines, were grown and evaluated at a half dozen sites in north-western Argentina in collaboration with bean scientists of EEAIOC and INTA. This in-country evaluation, among other things, has permitted us to identify locally adapted parents, hybrid populations, and families. Moreover, through these collaborative nurseries it was possible to evaluate for resistance to the bean chlorotic mottle virus, which is of great economic importance in Argentina. We were very pleased to learn that sources of resistance to CBB, BCMV, anthracnose, angular leaf spot, Empoasca, etc., identified in Colombia, have held up at all sites against local Argentinian populations over the last two years. Moreover, experimental lines of black beans, e.g., DOR 41 (ICTA-Quetzal) and DOR 60 (Negro Huasteco 81), carrying tolerance to BGMV in Central America and Mexico, were immune to the bean chlorotic mottle virus in Argentina. This will play a major role in the rapid replacement of the susceptible black seeded variety Negro Común in the near future.

19810

Genetic Improvement for the Andean Zone and Eastern Africa

Andean Zone

Crossing block and breeding plans

The Andean Region includes the inter-Andean valleys and slopes of Colombia, Ecuador, Perú and Bolivia. Venezuela is not included since the beans there are quite different ('caraotas'), nor are Chile or Argentina included. The irrigated coastal areas of Perú and Ecuador are not included as these represent special conditions. The region thus defined includes principally rainfed highland production areas, within the tropics, for both bush and climbing beans.

A crossing block of 420 varieties has been formed, including both bush and climbing bean types. In middle altitudes of the region, monoculture or row intercropping with maize is common, with bush (Type I), or semi-climbing (Types II and III) beans. At high altitudes climbing beans predominate, grown in mixed intercropping with maize, and frequently with other species such as broad beans (*Vicia faba*) and cucurbits. These cultivars are generally late (6-9 months to harvest) and extremely vigorous (Type IVB). They are sometimes grown as mixtures or land races, though this practice is disappearing gradually. The crossing block endeavors to include the important commercial cultivars of the region, plus improved lines and sources of resistance to anthracnose, ascochyta leaf spot, angular leaf spot, halo blight and storage insects. Crosses are made mostly in the field at CIAT-Palmira and Popayan, and some crosses are made in collaborative programs with ICA at La Selva and Obonuco. The objective of the improvement program is to obtain improved cultivars for yield in appropriate cropping systems with disease and pest resistance, and commercially acceptable grain type. Large grains, spherical or kidney shaped, colored red, cream, yellow or white and either solid or speckled, are preferred throughout the region. Important commercial cultivars of bush beans include: Diacol-Calima, Nima, Limoneño, Cargabello, Shaya and Red Kidney. Representative types of climbing beans include: Bola Roja, Cargamanto, Sangretoro, Radical, Mortiño, Bolon Bayo, Caballero, Canario, Ñuña.

The number of crosses made is shown in Table 1. Where they are intended for parts of the region other than Colombia, they are being managed in bulk according to the scheme outlined in Figure 1, designed to obtain a rapid advance of the generations and permit selection for local adaptation and yield stability in the later generations. Crosses designed for improving Colombian cultivars have been managed using a modified pedigree method as described in previous Annual Reports (CIAT, 1979).

Table 1. Responsibilities for character and cultivar improvement project of the three breeders of the Bean Program.

Research area	Responsible breeding program	No. of crosses made	
Character improvement			
Bean common mosaic virus	I[a]	127	
Bean golden mosaic virus	I	221	
Rust	I	21	
Common bacterial blight	I	101	
Halo blight	III	2	
Web blight	I	12	
Anthracnose	II	36	
Angular leaf spot	II	21	
Ascochyta leaf spot	III	76	
Mildew	III		
Bean scab	III		
Empoasca leafhoppers	I	183	
Apion pod weevil	I	29	
Storage insects	III	28	
Beanfly	III		
Mexican bean beetle	II	17	
Nematodes	III		
Drought	II	34	
Low temperature	III		
Low P	II	20	
Maturity	II	20	
N_2 fixation	I		
Architecture	II	21	
Snap beans	III	56	
		1025	
National cultivar improvement			
Black beans	I	121	
Central America	I	105	
Caribbean	I	40	
Coastal Mexico, Peru	I	186	
Other studies	I	307	
Brazil (non-black)	II	70	
Mexican highlands	II	162	
Argentina	II	119	
Andean Zone	III	274	
Africa	III	308	
		1692	2717

a. Breeding program: I = S. Temple; II = S. Singh; III = J. Davis.

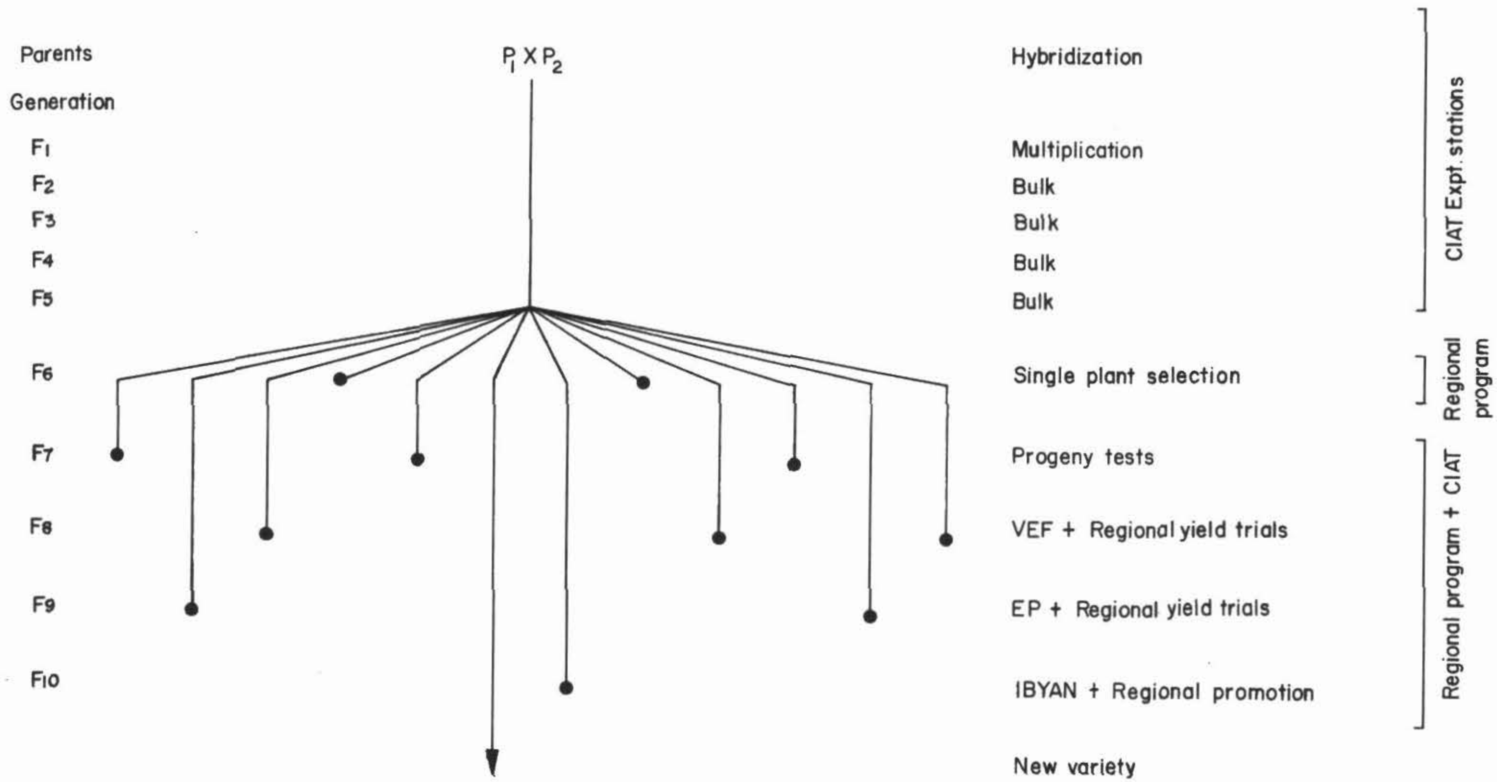


Figure 1. Bulk breeding method for rapid generation advance and local selection in the Andean Zone.

Breeding nurseries in CIAT-Palmira and Popayan

Breeding nurseries for medium altitude tropical climates are grown at Palmira and Popayan (1000 and 1750 masl respectively). A total of 1740 bush and climbing bean materials, consisting of germplasm collections from the Andean Region, were evaluated for parental selection, and the best were included in the crossing block.

Breeding populations in generations F_2 to F_7 were evaluated intercropped with maize. Field inoculations with anthracnose were made in advanced generations in Popayan. Materials were selected for resistance to BCMV according to evaluations made in the glasshouse. Resistance to ascochyta leaf spot, angular leaf spot and rust was selected for with natural field infection. Some segregating populations were also evaluated in the field, under extended daylength, to select for insensitivity to photoperiod.

Andean region materials in general are highly specifically adapted both to temperature and photoperiod, so that adaptability between Colombia and Southern Peru, for example, is rather poor. Broader adaptability is available in bush bean materials, but these are generally low yielding Type I varieties, and are highly susceptible to certain diseases, especially ascochyta leaf spot. Climbers tend to be more specifically adapted, but more resistant to certain foliar disease and higher yielding. Extensive crossing between growth habits is producing improved types of both climbers and bush.

In particular, the combined resistance to BCMV and anthracnose was not available in any Andean region commercial cultivars. Efforts have been directed towards combining these resistances in suitable grain types. Results for some F_5 lines are shown in Table 2, demonstrating progress in genetic improvement. These lines will now enter the VEF nursery.

Collaborative activities in Colombia

Since 1977 collaborative projects with ICA have been concentrated in two experiment stations: La Selva (Antioquia) and Obonuco (Nariño). The objective is to breed improved bean varieties for the tropical highlands, mostly for intercropping with maize, in relay at La Selva and in mixed intercropping at Obonuco. Collaborative work for medium altitudes has begun with ICA at El Arsenal, in Santander del Sur, and with CENICAFE in Chinchiná.

The first phase of germplasm selection and evaluation, followed by on-farm regional trials, has resulted in the release of a new climbing bean variety, named ICA-Llanogrande, selected from a collection originating in Southern Ecuador and previously known as E 1056. It was selected for field resistance to anthracnose, is suitable for relay or mixed intercropping with maize, and is exceptionally widely adapted to altitudes between 1,500 and 2,700 masl in the tropics. Three tons of foundation seed have been produced for distribution in demonstration trials.

Table 2. Results for F_5 lines with commercially acceptable grain types for the Andean Region, selected for improved yield and resistance to anthracnose and BCMV in Popayan.

Pedigree	Color	Days to flower	Habit	BCMV[a]	Anthracnose[b]	Ascochyta leaf spot	Angular leaf spot	Yield (kg/ha)[c]
V-5746-39-33	Cream/mauve	49	IVA	R	3	2	2.5	2398
V-5746-39-35	Cream/mauve	49	IVA	R	3.5	3	2	2149
V-5778-313-31	Cream/red	51	IVA	R	2.5	2	2	2822
V-5778-339-32	Cream/mauve	50	IVA	R	3.5	2	2	2060
V-5778-340-32	Cream/mauve	48	IVA	R	3	2	2.5	2100
V-5778-344-34	Cream/red	48	IVA	R	3	2.5	2	2048
V-5778-349-35	Cream/mauve	51	IVB	R	3	2.5	2	2489
V-5764-49-31	Cream/mauve	49	IVA	R	3	2	2.5	2756
G-5764-49-32	Cream/mauve	49	IVA	R	3	2.5	2	2421
V-5754-49-33	Cream/mauve	47	IVA	R	2.5	3	2	2107
V-5764-410-36	Cream/purple	51	IVA	R	2	3	2.5	2672
V-5764-417-32	Cream/purple	54	IVA	R	2	2	2	2040
V-5764-410-31	Yellow-coffee	51	IVB	R	3	2.5	3.5	2221
ICA-Viboral (control)	Cream/red	60	IVB	S	4	3	3	1378
LSD (5%)								382

a. Screenhouse test with necrotic race NL-3.
b. Field inoculated with anthracnose.
c. Yield in relay intercropping with maize.

Two climbing bean breeding lines V 8036 and V8038, have shown very promising results in regional trials at medium altitudes (1200-1800 m.) with the Federacion de Cafeteros. A bush bean line, BAT 1235, has also consistently outyielded local checks. Basic seed of these lines is being multiplied.

In Antioquia work is concentrated in ICA-La Selva (2,100 masl 17°C mean temp.), close by one of the most important bean production regions of Colombia, where collaborative on-farm trials are also being carried out. Relay cropping systems of potatoes-maize-climbing beans predominate. Bush beans are mostly intercropped with potatoes. All experiment station screening of climbing bean materials is carried out in relay cropping, and bush beans are screened in monoculture. The principal disease problems are anthracnose, ascochyta leaf spot and angular leaf spot, for which field resistance in commercially acceptable cultivars in being sought. These three diseases are noted for considerable pathogen variability, so that the ability to yield under non-protected conditions is considered more important than immunity. Some materials, such as E 1056, have been found to possess excellent field resistance to anthracnose, but are susceptible in seedling glasshouse tests.

Highly promising new selections from germplasm include five climbing bean collections from Guatemala and Peru, with satisfactory field resistance to all three diseases (Table 3). The best two of these have been included directly in on-farm regional trials, and all were included in the crossing block.

A total of 44 new climbing bean crosses were made in La Selva, principally sources of disease resistance crossed with ICA-Viboral, Calabozo, Radical, Liborino voluble and L 32980-M(8), representing the most commercial cultivars currently available. In bush beans, 9 new crosses were made in La Selva, between commercial cultivars Diacol Catío, ICA-Cuna and ICA-Toné (all Type I), crossed with Guate-432 (G 7908) and Ancash-66 (G 4727), which are both Type III with excellent field resistance to anthracnose and greater yield potential, especially in competition with potatoes.

Breeding populations from F_2 to F_5 were evaluated in unprotected field trials. In climbers, apart from improved disease resistance, the objective is to seek an even distribution of the pod load up the plant, to reduce the risk of lodging in the maize, and allow an increased density of planting of beans. Agronomic trials have indicated a benefit from reducing the distance between the maize hills, but this cannot be achieved with traditional bean cultivars, which are aggressively vigorous and susceptible to diseases. Disease severity has been found to increase with density of planting, so that improved disease resistance is required.

Advanced lines in the 1981 VEF were evaluated in La Selva and the best climbers included VRA 81022 and VRA 81044 (large red mottled) and VRB 81060 (small red). The most promising bush lines include A 483, BAT 1385 and 997-CH-73 (Table 5). Advanced breeding lines of climbing beans

Table 3. Promising selections from germplasm in ICA-La Selva (2100 masl), principally for use as parents, grown in relay cropping with maize.

CIAT no.	Identification	Anthracnose[a]	Ascochyta leaf spot[a]	Angular leaf spot[a]	Weight of 100 seeds (g)	Yield (kg/ha)	Grain color	Origin
G 10813	Guate - 1240	2	2	2	39	2467	Red	Guatemala
G 8525	Guate - 457	1	2	2	38	2445	Red	Guatemala
G 10820	Guate - 147	2	2	2	34	1765	White	Guatemala
G 11778	Canario	3	2	3	40	1455	Yellow	Peru
G 11796	Poroto	3	2	2	43	1332	Yellow	Peru
Control	Cargamanto	4	3	4	58	1102	Cream/ red	Colombia
LSD (5%)						864		

a. Evaluated on 1-5 scale: 1 = symptomless.

Table 4. The most promising lines from the 1981 VEF in ICA La Selva.

Identification	Growth habit	BCMV[a]	Anthracnose[b]	Ascochyta leaf spot[b]	Angular leaf spot[b]	Weight of 100 seeds (g)	Seed color
VRA 81022	IVA	V	1.5	2.0	3.0	40	Cream/red mottled
VRA 81044	IVA	R	1.5	3.0	2.0	42	Cream/black mottled
VRB 81060	IIIB	R	2.0	3.0	2.5	19	Red
A 483	IIIA	R	1.5	3.0	3.5	34	Red mottled
BAT 1385	I	R	2.0	4.0	2.5	36	Red mottled
997-CH-73	IIIA	R	2.5	3.5	2.5	30	Yellow

a. V = variable for presence of I gene. R = confined I gene resistance.
b. Evaluated on a 1-5 scale. 1 = symptomless.

Table 5. Experiment station yields, kg/ha, of the best advanced lines obtained in ICA La Selva in relay cropping with maize, unprotected.

Identification	Yield	Color
La Selva #2	1719	Cream/red mottled
La Selva #7	1719	Cream/red mottled
La Selva #1	1716	Cream/red mottled
La Selva #29	1696	Purple/cream mottled
La Selva #22	1685	Red/cream mottled
La Selva #15	1685	Cream/red mottled
ICA Llanogrande[a] (control)	1678	Cream/purple mottled
La Selva #20	1619	Cream/red mottled
La Selva #17	1614	Cream/purple mottled
La Selva #23	1588	Red
ICA Viboral (control)	1100	Cream/red mottled
LSD, p 5%	455	

a. Previously known as E 1056.

were planted in on-farm regional trials. The experiment station yields of the best of these are shown in Table 5. Although they do not represent a significant improvement on the new variety ICA-Llanogrande, they do have a more highly preferred (and higher priced) grain type. Progress can be measured by comparison with the previously released improved variety ICA-Viboral.

In Nariño, new advanced lines identified at Obonuco (2,710 masl, 13°C) are being tested in on farm-regional trials. Promising climbers for mixed intercropping with maize are: E 605 and E 521 (selected from Ecuadorian germplasm); L-33003 and L 32980-M(8) (selected from ICA breeding populations); several advanced lines from CIAT crosses (e.g. V-5797-23-41). Experiment station yields of some of these lines, intercropped with maize and compared with the local cultivar, Mortiño, are shown in Figure 2. In addition to consistently yielding more than Mortiño, these lines show superior resistance to anthracnose and halo blight, and are 40-50 days earlier to maturity. For this reason they have been found to do well with an earlier selection of maize, MB-521. Promising bush bean lines include L 33341 which is resistant to halo blight and exceptionally cold tolerant. These new lines are expected to offer improved productivity to small farmers in the Andean highlands.

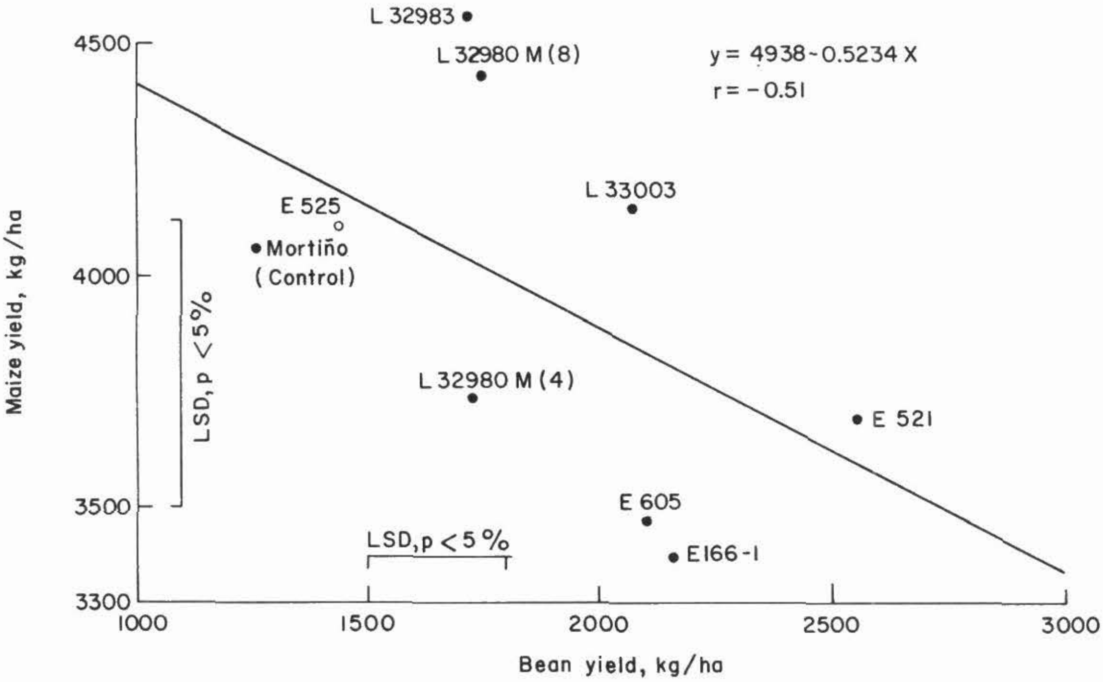


Figure 2. Yields of best advanced selections in Obonuco, intercropped with maize ICA V-507.

A total of 37 crosses were made in Obonuco, involving crosses between commercial cultivars for the cold highlands, and sources of disease resistance, principally to anthracnose and angular leaf spot. Breeding populations of climbers were evaluated in mixed intercropping with a selection from the local morocho land race of maize. Bush beans were evaluated in monoculture. Results for the most promising F_5 advanced lines are summarized in Table 6. These have been included in on-farm regional trials.

Collaborative activities in Ecuador and Peru

Collaboration with INIAP in Ecuador is based at Santa Catalina (2700 masl), near Quito, at Chuquipata experiment station (2200 masl) near Cuenca (Azuay) for the highlands, and on the coast at Boliche experiment station, near Guayaquil. In the Peruvian highlands, collaborative work with INIPA is underway at Cajabamba (2600 masl), department of Cajamarca, and at Mollepata (2680 masl) near Cuzco. In the inter-Andean valleys most beans are grown in rainfed conditions, and in the higher parts above 2,200 masl climbing beans intercropped with maize predominate. Bush beans are grown at lower altitudes mostly in monoculture, and sometimes with irrigation. Beans with large grain size are preferred, colored cream (bayo), yellow (canario), white (caballero) or red. In Ecuador approximately 95% of the area in bean production is found in the Andean highlands, and in Perú it is approximately 47% of the total area.

Table 6. The most promising F_5 and advanced lines selected in Obonuco, intercropped with maize ICA V-507.

Line no.	Pedigree	Days to flower	Anthracnose	Ascochyta leaf spot	Halo blight	Rust	Yield (kg/ha)	Weight of 100 seeds (g)	Color
177	V-5797-23-41	107	2	3	1	2	1632	56	Muave
227	32976-m(4)-ma-m-1-41	107	3	1	2	4	1617	61	Red
234	32980-m(4)-ma-mb-1-41	107	1	1	2	1	1657	69	Cream/muave
236	32980-m(4)-ma-mb-1-43	113	1	2	1	2	1978	57	Muave
237	32980-m(4)-ma-mb-1-44	110	3	2	1	1	1632	54	Muave
	Mortiño (control)	122	4	2	1	1	801	89	Purple/cream
	LSD, p 5%						455		

As in Colombia, the climbing bean selection E 1056, originating from the Ecuadorian collection, has shown significantly higher yields than local commercial cultivars both in Cajabamba and in Santa Catalina. Its field resistance to anthracnose has been confirmed in both locations, and in regional trials in the northern department of Imbabura, Ecuador, it has shown consistently superior results. It has recently been named INIAP-Imbayas by the Ecuadorian program. Approximately 150 kg of breeders' seed was available in Ecuador for on-farm trials in September 1982. In northern Perú another line which had been introduced through the VIRAF trials of climbing beans for intercropping with maize has shown superior yield performance, earliness and resistance to anthracnose when compared to the local cultivar, 'Caballero'. It was known as G 2829 and has recently been named 'Gloriabamba'. Approximately 200 kg of breeders' seed was available for multiplication by April 1982. Other materials with outstanding performance in the Andean Region VIRAF trials, for use mostly as parents in the breeding program, are G 858, G 2331 and G 2333.

Bush bean advanced lines in the EP and IBYAN have been evaluated and the following lines look particularly promising for middle altitudes (up to 2,200 masl): BAC 42, BAC 43, BAT 338, BAT 482, BAT 1061, BAT 1235, BAT 1272, BAT 1274, BAT 1276 and BAT 1297. In addition, ICA lines L-17 ('ICA-Palmar') and L-23 have shown improved disease resistance and yield.

The crossing block for the Andean region includes the important commercial cultivars of climbers and bush beans, the best improved lines, and the latest sources of resistance to the principal diseases (anthracnose, ascohyta leaf spot, angular leaf spot, halo blight). In addition to Colombian locations it has been planted in Santa Catalina Chuquipata, Ecuador, and in Cajabamba and Mollepata, Perú. Evaluations of the materials in these locations will provide information on the value of potential parents. New hybrid combinations for crossing in Colombia will be selected on the basis of evaluations made in the region. Segregating populations are being advanced up to F_5 in bulk in Colombia, for local selection in F_6 in order to assure suitable local adaptation.

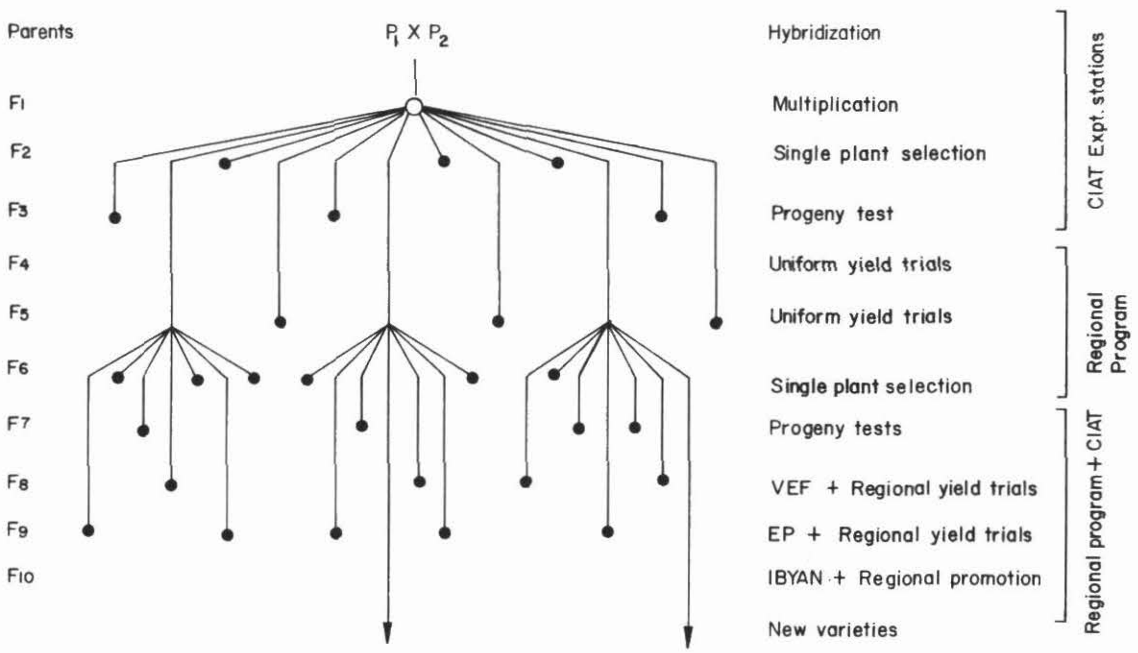
Eastern Africa

Crossing block and breeding plans

Based on recommendations from the regional workshop held in Malawi in March 1980, follow-up visits by CIAT staff, and the training in CIAT of 11 scientists from Kenya, Tanzania and Rwanda, objectives for the genetic improvement of commercial bean types in Eastern Africa have been set. The countries considered within the region are Rwanda, Burundi and the Kivu region of Zaire; Uganda, Kenya and Tanzania; and Malawi, Zambia and Zimbabwe. Beans are mostly grown at middle altitudes from 1000 to 1800 masl, with some locally important production at higher altitudes up to 2,400 masl. Altitudes in general are lower than in the Andean Region and bush beans are relatively more important. Bean production in the region as a whole is estimated at 1.4 m. tons per year (Proceedings Regional Workshop on Potential for Field Beans in Eastern Africa, Lilongwe, Malawi, 1980) but this may be an under-estimate. Like the Andean region beans are commonly intercropped with maize, and sometimes with other crops. Preferences for grain types are largely similar to those encountered in the Andean Region, and anthracnose, angular leaf spot common bacterial blight and halo blight are common disease problems. Relatively more important is BCMV, and especially virulent races of this virus are found in the region, overcoming resistance confirmed by the 'I' gene with a necrotic reaction known as 'Black root' in some areas. Problems not encountered in the Andean Region include Bean Fly (Ophiomya phaseoli) and Bean Scab (Elsinoe phaseoli).

A crossing block of 474 varieties, including bush and climbing beans, has been formed, consisting of some commercial cultivars in Africa and selected lines offering suitable pest and disease resistance. It has been planted in four middle altitude zones of Colombia and has been sent to Chipata (Zambia), Lyamungu (Tanzania) and Rubona (Rwanda). Field evaluations made in the region will guide the choice of parental combinations used in crossing.

Most of the breeding populations destined for Africa are being handled according to the scheme outlined in Figure 3 and known as the F_2 progeny method. It offers the advantage of a generation (F_3) for clean seed production, and to assure resistance to BCMV, before materials are dispatched for local selection. It is a decentralized breeding method whose success will largely depend on the formation of a CIAT regional program in Eastern Africa.



Fiugre 3. The F_2 progeny method for selecting regional adaptation and yield stability in beans.

Breeding nurseries in CIAT-Palmira and Popayán

Although information on the most suitable parents remains to be collected, important disease resistance and improved yield can be incorporated in materials with suitable grain types in CIAT. Extensive hybridization between cultivars from Africa and sources of resistance to diseases and stress factors have been carried out in 1982 (Table 1). F_2 single plant selection nurseries have been planted. Shipping of early generation hybrid populations for selection in Africa awaits the establishment of the regional program, although close ties with the Title XII project in Tanzania and the World Bank project in Zambia will enable a start to be made.

Progress in the breeding of early generation populations of suitable grain colors is shown in Tables 7 and 8. Emphasis has been given to improving resistance to BCMV and rust, as well as improved yield for intercropping with maize. Conditions in the F_3 progeny trial were generally poorer than those in the F_5 yield trial, as evidenced by the yield of the control variety. Nevertheless, some of the F_3 lines yielded as well as the advanced lines, demonstrating the potential of the more recent crosses, all of which involve CIAT lines as one of the parents. Higher yields, on the other hand, are somewhat correlated with later flowering, which is an undesirable trend for some areas. BCMV resistance, controlled by the 'I' gene, is important to assure the shipping of seed free of virus from Colombia, but new sources of resistance will need to be incorporated for areas where 'black root', caused by virulent races of BCMV, is a problem.

Variety mixtures are commonly grown in many parts of Africa, and introduced varieties may have to compete in these mixtures. The testing of all breeding populations in intercropping systems tends to result in the selection of materials with high competitive vigor which are expected to perform well both in variety mixtures, and intercropped with other species.

Table 7. Early generation (F_3) breeding lines in progeny yield trial, compared with Rojo 70 in relay intercropping with maize, CIAT-Palmira.

Line no.	Pedigree	Days to flower	BCMV[a]	Rust	Yield (kg/ha)	Color	Parents
75	V-7950-129	39	Vb	1	1215	Red	G 0685 x V 79119
125	V-7952-121	39	Vb	1	1431	Red	G 3913 x V 7918
359	V-7960-115	38	R	1	1267	Red	G 7128 x V 79119
582	V-7967-169	39	R	2	1232	Red	G 2025 x V 7920
58	V-7953-165	41	R	2	1233	Yellow	G 3913 x V 7920
-	Rojo 70 (control)	38	S	3	516	Red	-
	LSD, p 5%				373		

a. Glasshouse test with NL-3
R = confirmed presence of "I" gene for resistance.
Vb = variability for presence of "I" gene.

Table 8. Advanced breeding lines with medium sized grains, color red, cream, and white, compared with controls Rojo 70 (red) and G 2540 (white) in relay intercropping with maize, CIAT-Palmira.

Line no.	Pedigree	Days to flower	BCMV[a]	Rust	Yield (kg/ha)	Color	Parents
177	V-4613-313-17-13	40	R	3	1270	Muave	G 5653 x G 3872
544	V-4616-39-21-14	42	Vb	3	1315	Red	G 5653 x G 3872
545	V-4616-39-21-15	41	Vb	3	1219	Red	G 5653 x G 3872
776	V-4612-34-114-11	38	R	3	1421	Cream/black	Rojo 70 x G 2006
977	V-4621-13-14-14-11	38	(R)	2	1770	Cream	Rojo 70 x G 2006
979	V-4621-13-14-14-13	38	(R)	3	1522	Cream	G 3445 x G 2540
980	V-4621-13-14-14-14	38	(R)	3	1490	Cream	G 3445 x G 2540
1104	V-6201-16-15-14	43	R	2	1407	Pink	G 2525 x G 2333
1188	V-4609-317-21-111	44	R	3	1435	Cream/black	G 2839 x G 3872
1350	V-4621-13-11-21-15	38	(R)	3	1547	White	G 3445 x G 2540
	Rojo 70 (control)	36	S	4	1012	Red	-
	G 2540 (control)	39	S	4	874	White	-
	LSD, p 5%				697		

a. Glasshouse test with NL-3
R = confirmed presence of "I" gene for resistance.
(R) = symptomless.
Vb = low % variability for presence of "I" gene.

Collaborative Activities

Rwanda: Approximately 300 materials from CIAT are currently being evaluated, including EP 82 and IBYAN trials, in three locations: Karama, Rubona and Rwerere, at 1400, 1640 and 2300 masl respectively. These evaluations will provide important information on the adaptation of CIAT breeding lines to local conditions. Promising results have so far been obtained at Karama and Rubona with BAT 1297 (medium sized red), BAT 202, BAT 41, A 21 (small reds). Results for materials adapted to the cool conditions at Rwerere are not yet available.

Burundi: Advanced lines from CIAT have not yet done better than Diacol Calima, introduced in the 1976 IBYAN. However, BAT 1297 has given particularly promising results in the Mosso region. Collaboration on the search for improved resistance to bean fly by means of selection in interspecific hybrids is underway.

Kenya: Quarantine restrictions have caused a delay in the evaluation of EP and IBYAN materials, so that results are not yet available.

Tanzania: Trials have been sent to Lyamungu, Morogoro and Uyole. Collaborative activities are being coordinated through the Title XII project, based at Morogoro (University of Dar-es-Salaam). Collaboration to seek bean fly resistance is planned. Promising results have been obtained with BAT 41 in Zanzibar.

Malawi: IBYAN trials have demonstrated promising results. Climbers are relatively more important in Malawi than in other countries. It is hoped to establish links with the Title XII project which is studying variety mixtures.

Zimbabwe: Promising results have been obtained with BAT 1296, BAT 1297 and BAT 1230 (medium sized reds); BAT 332, BAT 561 and A 81 (small cream); V 7916 (small red). Collaboration with the Department of Research and Specialist Services is planned at the following principal research stations: Gwebi Variety Testing Centre (1,448 masl), Cotton Research Institute, Gatooma, (1,157 masl) and Chiredzi Research Station (600 masl). In addition, projects related to adaptation studies and nitrogen fixation are planned with the University of Zimbabwe.

Zambia: Close links are being formed with the new grain legume project being established at Chipata. The crossing block, EP82 and IBYAN trials have been sent for evaluation.

9811

Green Bean Improvement

Compared to dry bean breeding, the genetic improvement of snap beans is of relatively low priority. Nonetheless there is great interest in such short-duration crops, and in some countries green beans constitute the principal form of Phaseolus vulgaris consumption.

During 1981-1982 the CIAT germplasm bank of snap bean entries (400 lines) were evaluated in one or more environments, along with a number of new commercial varieties and breeding lines from public institutions in the United States. As a result of this preliminary evaluation, 16 lines were chosen for testing in three locations as part of a student thesis. Results showed that productivity and quality were quite acceptable for several genotypes in each of the locations tested, and parental stocks for snap bean crosses were identified. Some 59 crosses were made for bush snap bean improvement in 1982, and a large number of F_2 selections were made in segregating populations.

Potential parents for breeding climbing snap beans were also evaluated, and the best in the collection, apart from Blue Lake (G 8992) were G 8105, G 8776 and G 3736 (Table 1). The last two produced significantly more of their yield at the first harvest (48 days) than at the second (65 days).

Both climbing and bush snap beans have potential in certain parts of Latin America. Rapid progress should follow the incorporation of resistance factors into physiologically adapted but otherwise susceptible snap bean cultivars. Snap bean pod quality characters for processing are of extremely high priority in the United States and Europe, but in developing countries less rigid consumer standards offer greater opportunities to work with indeterminate bush plant types, and with this the array of plant protection advantages that appear to come from indeterminacy.

Table 1. The best climbing snap beans from the germplasm collection, evaluated at CIAT-Palmira. Yield of fresh pods, kg/ha.

CIAT no.	Identification	Yield[a]	Yield[b]	Total yield (kg/ha)
G 8105	Haricot-a-Rames	1519	2575	4094 A
G 8776	Genuine Cornfield	2654	1063	3717 A
G 3736	Alabama-1	1950	1692	2642 AB
G 8992	String Blue Lake (control)	1010	1788	2798 B

a. Harvest at 48 days after sowing.
b. Harvest at 65 days after sowing.

Occurrence of F_1 Hybrid Dwarfism in Crosses between Bean Lines of different Seed Sizes

In bush beans, small seeded varieties usually outyield those with medium and large seeds (Table 1). In favorable growing conditions this difference in yielding ability can easily exceed 1500 kg/ha. There also appears to be relatively higher frequency of resistance to desirable traits such as common bacterial blight, BCMV, BGMV, bean chlorotic mottle virus, root rots, etc., in small seeded varieties, probably due to their longer breeding history and agroclimatic distribution. In Latin America, small seeded beans are grown in relatively warm lowlands and medium and large seeded varieties predominate in cooler highland areas. In 1977, a breeding project for improving yield ability _per se_ of beans was initiated at CIAT. As a result, evaluation and utilization of bean germplasm bank accessions from different agroclimatic regions in the breeding programs has continued to increase. Unfortunately the frequency of F_1 hybrid dwarfism (Figure 1) in our nurseries also increased. This phenomenon of retarded growth or stunting often leading to eventual death of the F_1 hybrids is similar to the crippled character observed before. It is now known that the trait is under the control of two complementary independent dominant genes, DL_1 and DL_2. In the last five years, hybrid dwarfism has been recorded in over 80 different crosses. In an attempt to study the distribution of the genes causing hybrid dwarfism and their possible association with certain bean types, 17 accessions and experimental lines, previously known to show this trait in various hybrid combinations in our nurseries, were grouped according to their geographic origins. All possible diallel crosses were made among the members within each of the four groups: West Germany, Turkey, Brazil, and the miscellaneous. The latter group included bred lines from CIAT, Chile and Colombia's national programs. Crosses were also made between selected representatives from each group.

Table 1. Difference in yielding ability of small and large seeded lines of bush beans.

Small black		Medium & large red	
Mean	Maximum	Mean	Maximum
2273[a]	2802 (BAT 945)	1948[b]	2082 (ICA L 23)

a. Average of 14 lines.
b. Average of 8 lines.

SOURCE: IBYAN 1981 conducted at CIAT-Palmira.

Figure 1. Occurrence of F_1 hybrid dwarfism in crosses between bean linea of different seed sizes.

In all cases where F_1 hybrid dwarfism occurred, one parent always had small and the other medium or large seeds. In order to test this observation further, all parents were divided according to seed size into two groups: small versus medium and large seeded, irrespective of their geographic origins. There were four entries in the small and 13 in medium and large seeded types. Because the F_1 hybrids among all medium and large seeded lines of each group were normal, one accession form each of the four original groups was chosen for further studies. Thus, four lines from each small and medium- or large-seeded groups were crossed in a diallel fashion (Table 2) and to a common tester parent selected from the contrasting seed size group (Table 3). Also all 13 medium or large and 3 small seeded lines were crossed to BAT 332, which had smal' seeds (Table 4). Results show that all F_1 hybrids made among either small or medium and large seeded lines were normal and that the F_1 hybrid dwarfism occurred only when a line from one group was crossed with the other group. Thus, the bean accessions of two distinct seed sizes have complementary genes for hybrid dwarfism which alone are unable to suppress the growth and development of bean varieties. Also all four small seeded types have similar genetic factor. Likewise all 13 medium and large seeded forms have a different but identical gene, irrespective of their geographic origins. It should, however, be noted that not all crosses between small and medium or large seeded bean lines give hybrid dwarfism. But we have not been able to recover the high yield potential of small seeded varieties into medium and large seeded types, so far.

Table 2. Development of F_1 hybrids between crosses of small and medium seeded bean accessions.

Small seeded

Female \ Male	Carioca	G 7148	BAT 332	BAT 1061
Carioca	-	Normal	Normal	Normal
G 7148		-	Normal	Normal
BAT 332			-	Normal
BAT 1061				-

Medium seeded

Female \ Male	G 623	G 5066	G 7633	Tortolas Diana
G 623	-	Normal	Normal	Normal
G 5066		-	Normal	Normal
G 7633			-	Normal
Tortolas Diana				-

Table 3. Development of F_1 hybrids between medium and different small seeded lines and small and different medium or large seeded lines.

Medium and different small seeded lines

Female[a] \ Male[b]	Carioca	G 7148	BAT 332	BAT 1061
G 623	Dwarf	Dwarf	Dwarf	Dwarf

Small and different medium seeded lines

Female[a] \ Male[b]	G 623	G 5066	G 7633	Tortolas Diana
Carioca	Dwarf	Dwarf	Dwarf	Dwarf

a. Medium seeded.
b. Small seeded.

Table 4. Development of F_1 hybrids between accessions of different seed sizes and a common tester parent, BAT 332.

Female	Male BAT 332[a] F_1 hybrid
Small seeded	
Carioca	Normal
G 7148	Normal
BAT 1061	Normal
Medium or large seeded	
G 153	Dwarf
G 568	Dwarf
G 623	Dwarf
G 910	Dwarf
G 5066	Dwarf
G 5129	Dwarf
G 7613	Dwarf
G 7633	Dwarf
L 23	Dwarf
Tortolas Diana	Dwarf

a. Small seeded.

Heterosis and Inbreeding Depression in Crosses of Dry Beans

Twelve bush bean lines of different geographic origins, growth habits, and seed sizes were selected in 1978 for estimation of heterosis and inbreeding depression. Two parents, one each of type I and III, and their crosses were subsequently dropped due to the F_1 hybrid dwarfism. A trial involving 10 parents and 13 F_1 hybrids was conducted for three years. The F_2 populations were evaluated in the trial of 1982. Of several characters recorded on the parental lines, the mean values for grain yield, weight of 50 seeds, number of seeds per pod, and number of pods per plant for the trial conducted in 1982 are given in Table 1. While differences among genotypes were statistically significant, the mean values of the F_1 hybrids were not significantly greater than that of the highest line for any of the characters (Table 2).

All three crosses with high positive heterotic values (Table 3) involved parents with different seed sizes and/or growth habits. Only one cross, A 30 x A 23, whose both parents possessed small seeds showed positive heterosis for seed weight. But statistically significant values of all other crosses for grain yield, seed weight, seeds per pod, and number of pods per plant were negative. While two of the heterotic crosses for grain yield showed marked inbreeding depression in the F_2, to our great surprise, the mean values for the F_2 of four crosses was significantly higher than their respective F_1 hybrids. Some crosses will be repeated in order to verify these results.

Table 1. Mean values for grain yield and its components for 10 dry bean lines grown at CIAT-Palmira in 1982.

Identification	Growth habit	Grain color	Grain yield (kg/ha)	Weight of 50 seeds	No. of seeds/pod	No. of pods/plant
ICA L 23	I	Marron mottled	2287	21.4	4.4	17.0
G 4770	I	Black	2370	8.5	5.8	33.2
G 3807	I	Cream	1980	10.8	5.9	29.4
A 23	II	Brown mottled	2099	11.1	5.8	24.8
A 30	II	Beige	2269	9.5	5.9	34.6
G 4000	II	Gray	2469	9.7	6.8	28.8
G 5066	II	Pink mottled	2190	20.4	4.9	20.0
A 21	III	Marron	2372	12.7	6.9	27.2
Carioca	III	Cream striped	2602	12.8	5.8	25.4
G 7148	III	Cream	3101	10.1	6.2	32.9
Mean			2373.9	12.7	5.8	27.3
CV			13.3	7.9	5.6	14.3
LSD (0.05)			580.3	5.4	0.5	6.5

Table 2. Mean values for grain yield and its components for thirteen crosses in F_1 and F_2 generations of dry bush beans grown at CIAT-Palmira in 1982.

Identification	Grain yield F_1	Grain yield F_2	Weight of 50 seeds F_1	Weight of 50 seeds F_2	No. of seeds/pod F_1	No. of seeds/pod F_2	No. of pods/plant F_1	No. of pods/plant F_2
ICA L 23 x G 3807	3143	2702	14.1	14.1	5.4	5.6	23.9	28.3
G 4770 x A 23	2030	2624	11.0	10.8	5.9	5.8	26.4	30.3
G 3807 x G 5066	2197	3142	14.3	14.7	5.6	5.4	28.7	28.2
ICA L x A 30	3178	2418	16.0	15.2	5.0	5.2	25.6	24.3
G 3807 x Carioca	2875	3146	13.2	11.7	6.1	6.0	29.9	31.8
A 23 x G 5066	3023	3103	15.9	14.9	4.7	5.2	24.2	28.9
A 30 x A 23	2792	2769	13.5	12.5	6.0	5.6	25.5	28.3
G 4000 x A 30	2488	2966	11.3	11.0	6.1	5.8	27.2	29.1
G 4000 x Carioca	2719	2604	13.0	11.3	5.4	6.6	27.8	26.2
G 5066 x A 21	2615	2097	16.2	15.4	5.1	5.2	26.9	29.6
A 23 x G 7148	2329	2394	11.6	11.5	5.7	6.2	29.9	38.2
A 21 x Carioca	3225	3384	14.1	12.6	5.3	6.1	24.7	28.1
Carioca x G 7148	3089	3953	12.2	12.4	5.7	5.8	29.8	28.3
Mean	2746.4	2869.4	13.6	12.9	5.5	5.7	26.9	29.2
CV	13.29		7.91		5.62		14.32	
LSD (0.05)	580.3		5.4		0.521		6.49	

Table 3. Heterosis over the superior parent and inbreeding depressions for yield and its components in thirteen crosses of dry bush beans.

Identification	Grain yield F_1	Grain yield F_2	Weight of 50 seeds F_1	Weight of 50 seeds F_2	No. of seeds/pod F_1	No. of seeds/pod F_2	No. of pods/plant F_1	No. of pods/plant F_2
ICA L 23 x G 3807	37.4*	18.2	-34.3*	-34.1*	- 8.9	- 5.0	-18.5	- 3.6
G 4770 x A 23	-14.3	10.7	- 1.2	- 2.7	- 1.1	- 0.6	-20.6	- 8.8
G 3807 x G 5066	0.3	43.5*	-29.9*	-27.9*	- 5.0	- 9.5	- 2.5	- 4.1
ICA L 23 x A 30	38.9*	5.7	-25.2*	-28.9*	-15.2*	-11.8*	-26.2*	-29.7*
G 3807 x Carioca	10.5	20.9	3.1	- 8.6	3.4	1.7	1.6	8.2
A 23 x G 5066	38.1*	41.7*	-22.1*	-27.1*	-17.9*	-10.4	- 2.4	16.6
A 30 x A 23	23.0	22.0	20.9*	11.9	1.7	5.6	-26.5*	-18.4
G 4000 x A 30	0.7	20.1	17.2	14.1	- 9.4*	- 3.8*	-21.5	-15.9
G 4000 x Carioca	4.5	0.1	1.8	-11.5	-20.7*	- 2.5	- 3.7	- 9.2
G 5066 x A 21	10.2	-11.6	-20.6*	-24.5*	-25.2*	-23.8*	- 1.2	8.8
A 23 x G 7148	-24.9	-22.8*	3.9	3.3	- 8.5	- 0.5	- 9.3	15.9
A 21 x Carioca	23.9	30.0*	10.7	- 1.0	-22.3*	-11.2*	- 9.4	3.2
Carioca x G 7148	- 0.4	27.5*	- 4.4	- 2.6	- 7.5	- 6.4	- 9.5	-14.3

* Significantly different from the high parent at the .05 level of probability.

Adaptation to Cropping Systems

While considerable research in the past has been devoted to the interaction of varieties with different cropping systems (intercropping with maize versus monoculture), a selection program of segregating generations carried out simultaneously in several systems had not been carried out. Such a trial was set up in 1982 involving F_3 progeny, descended from F_2 single plant selections, of all growth habits. These were grown in monoculture, and intercropped in rows with three maize cultivars: Población 30 (short stature, early), Suwan-1 (intermediate stature, intermediate time to maturity) and La Posta (tall stature, late to maturity). The objective was to test the hypothesis that breeding lines could be selected either for wide adaptability to cropping systems, or for specific adaptation to intercropping with a particular type of maize. If shown to be worthwhile, future breeding populations for intercropping could be selected with two or more tester maize genotypes to select for combining ability.

The project was initiated in F_3, but is being continued through the succeeding generations up to F_6, in order to discover whether the products of selection in several systems would be different. A total of 150 F_3 progeny were included, divided into 30 families (crosses), 10 of which were Type I growth habit (bush), 10 were Type II or III, and 10 were Type IV (climbing). It was found that correlations between the yields of Type I bean families in the four cropping systems were relatively high, indicating that mostly the same families would be selected in any system. For the Type II and III families, correlations between yields in monoculture and intercropping were very low, but between different maize intercropping systems the correlations were relatively high. For Type IV families, none of the correlations were significant, indicating a high degree of specificity of adaptation to different cropping systems. The relationship between the performance of families in F_3 and F_4 is being studied in the same cropping systems, and single plant selections are being taken in F_4. After several generations it will be possible to study any divergent tendencies that may emerge.

The mean yields for the different growth habits of beans, when intercropped with the three cultivars of maize, are shown in Figure 1. The best combination was obtained with La Posta and Type IV families (both tall). The poorest yields were obtained with Type I beans and Población 30 maize (both short statured).

Part of the effect of maize on beans is due to the support it offers for climbing. In order to study the extent to which the interaction of bean genotypes by cropping systems could be explained in terms of the height of the support, a trial was carried out with advanced breeding lines of the major growth habits (Figure 2). When no artificial support was given, all the lines yielded approximately the same. As bamboo stakes 1 and 2 m tall were added, progressively more yield was obtained with the more aggressive climbers. This results in a large genotype x support height interaction, and may explain part of the effect of intercropping with short maize cultivars (e.g., Población 30), or tall ones (e.g., La Posta).

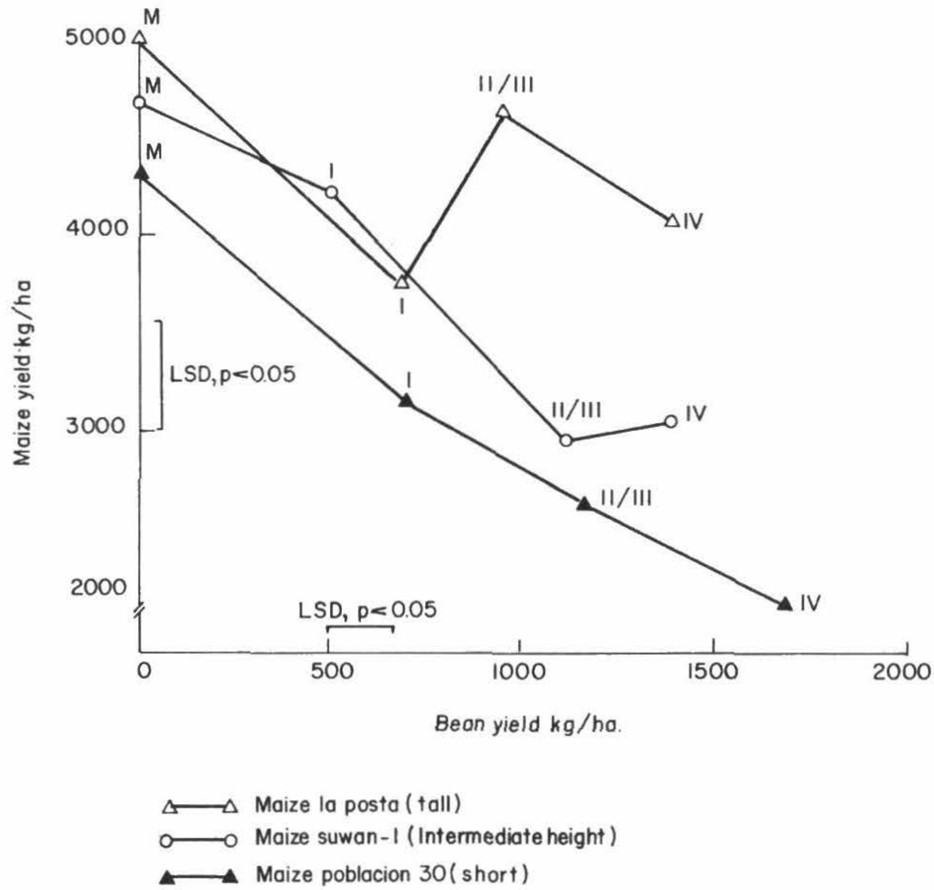


Figure 1. Mean yields of F_3 families of beans of growth habits I, II, and III (grouped together), and IV, intercropped with three cultivars of maize. M = monoculture maize. I, II/III, IV = growth habits of beans.

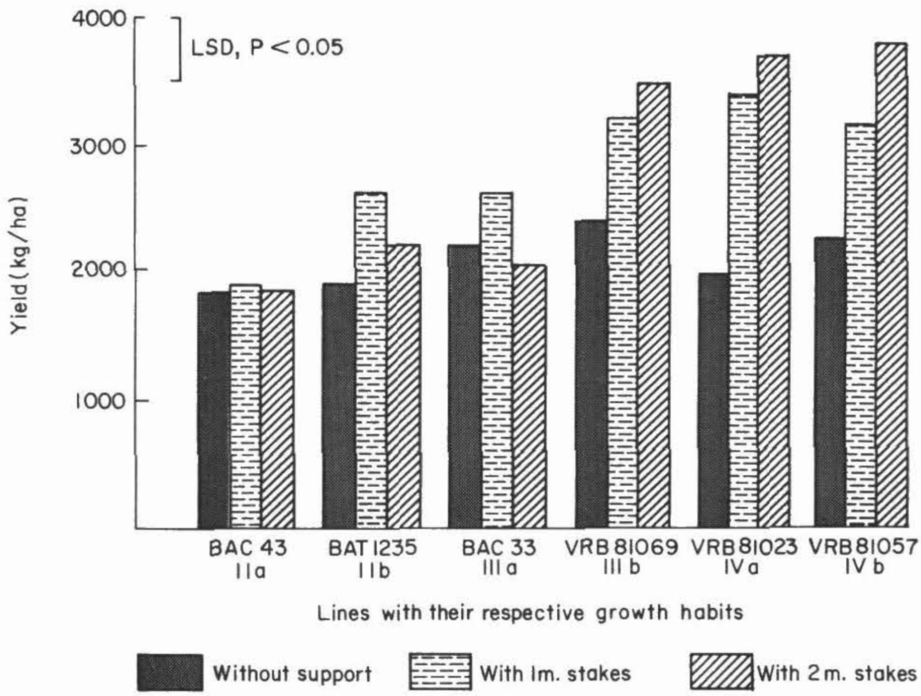


Figure 2. Yields of advanced lines of beans (red grains) of different growth habits with and without stakes. Bamboo stakes were 1 m and 2 m tall.

Progeny Evaluation in Uniform Nurseries

The three-phase system for evaluation and distribution of experimental lines was formed by the following amount of new genetic materials:

1. The Bean Team Nursery, 1981 VEF: 1101 entries
2. The Preliminary Yield Trials, 1982 EP: 304 entries
3. The International Bean Yield and Adaptation Nursery (IBYAN), 1982 IBYAN: 66 entries

The VEF was grown between July 1 and December 31, 1981 and was reported in last year's annual report. The 1982 EP was evaluated between January 1 and December 31, 1982 and the results for the first semester are reported herein. The 1982 IBYAN trials were distributed between January 1 and December 31, 1982. Partial results of 1982 IBYAN and a summary of 1981 IBYAN are given in this report. Complete results of IBYAN trials are given in special publications, two years after the last trial was dispatched.

The Bean Team Nursery, 1982 VEF

Since 1978, the Bean Team Nursery, the first uniform evaluation nursery in the system known as VEF, was conducted yearly from July 1 to December 31. This year the decision was taken to give one-year duration to the VEF nursery so no official 1982 VEF was conducted. This decision was made because nearly all national programs are testing improved germplasm and the detection of the second step of improvement requires more careful evaluation. The next VEF, the 1982 VEF, will be conducted from January 1 to December 31, 1982. Entries selected from this VEF will form the 1984 EP to be evaluated in that year and from this nursery, lines for the 1985 IBYAN will be chosen.

The Preliminary Yield Trial, 1982 EP

The 1982 EP trials of 304 entries distributed in 14 seed size and seed color groups:

Group (no.)	Growth habit	Seed color	Seed size	Climatic or geographic adaptation	No. of entries
10000	Bush	Black	Small		31
2000	Bush	Red	Med/large		34
20500	Bush	Red, red mottled	Small		53
30000	Bush	White	Med/large		11
30500	Bush	White	Med/large		13
40000	Bush	Cream, yellow light tan	Med/large	South Pacific coast	23
40500	Bush	Cream, light tan solid, mottled and stripped	Med/large	Mexico: dry and humid temperate zones	18
50000	Bush	Cream	Small/med	Brazil	56
60000	Climbing	Black	Small	Cold	7
60500	Climbing	Black	Small	Warm	2
70000	Climbing	Red	Med/large	Cold	25
70500	Climbing	Red	Med/large	Warm	16
8000	Climbing	Light	Med/large	Cold	7
80500	Climbing	Light	Small/med	Warm	8

Of these 304 entries comprising the EP, 239 were bush and 65 of the climbing growth habit. The EP trials were conducted at Palmira and Popayan during two semesters. The EP was conducted at both locations under protected and non-protected conditions, with the exception of the trial at Palmira in the first semester.

As a group the medium and large white-seeded varieties outyielded the other groups under protected conditions, however, this may be due to the small number of entries tested. Small black, small white, and small cream-seeded groups of entries appeared to yield statistically equal as the highest yielding group. Without chemical protection yield figures changed completely for white and black beans. In any event yields were low and CV too high to elaborate further on these results from both Palmira and Popayan (Table 1). Heavy rains and flooding of the fields contributed to the low yield.

The outstanding materials in each of the seven groups of bush varieties are listed in Table 2. The criteria for selecting these varieties was the above average yield performance in their respective groups at Popayan both under protected and non-protected conditions. From these groups of selected entries, those which also showed an average yield at Palmira were chosen. The entries were considered to have a wide adaptation. Using the above criteria only in two cases were checks included among this group of selected materials. Of the 42 materials chosen for good performance at Popayan, 28 showed above average yields in Palmira as well.

Table 1. Mean yield (kg/ha) of the different color groups of bush beans forming the 1982 EP. Palmira and Popayan, semester A.

			Popayan				
			With chemical protection	Without chemical protection			Palmira
Code	Group description		Yield[a]	Yield[a]	Difference	Rank	Yield[a]
30500	Medium/large	White	1489 a	222 b	1267	7	521 bc
10000	Small	Black	1266 a	699 a	567	5	765 ab
30000	Small	White	1209 a	472 b	737	6	680 abc
50000	Small	Cream	1143 a	779 a	364	2	811 a
40500	Medium/large	Pinto	1014 ab	731 a	283	1	620 abc
20000	Small	Red	969 ab	444 b	525	4	630 abc
40000	Medium/large	Light tan	941 ab	416 b	525	4	486 c
20500	Medium/large	Red, red mottled	740 b	430 b	310	3	462 c
Mean			1080	623			635
C.V. (%)			39.4	39.4			33.8

a. Numbers followed by the same letter did not differ by Duncan's Multiple Range Test at 5% level of probability.

Table 2. Selected bush bean lines with above average yield performance (kg/ha) under protected and non-protected conditions in the 1982A preliminary yield trial at Popayan.

Line	Popayan			Palmira
	With chemical protection	Without chemical protection	Difference	Without chemical protection
Black-seeded				
A 231	1854	1050	804	-
BAT 527 (C)	1737	1636	101	819
BAC 93	1703	1078	625	828
A 237	1687	946	741	888
A 227	1478	1352	126	-
Group mean	1266	699		765
Small, red-seeded				
BAC 90	1886	886	1000	715
BAT 1670	1801	502	1299	683
BAT 1654	1649	697	952	695
BAT 1493	1614	718	896	690
BAT 1336	1319	683	636	-
BAT 1570	1166	524	642	804
BAT 1577	1126	938	188	857
BAT 1489	1011	767	244	-
BAT 1572	969	543	426	708
Group mean	969	444		630
Large, red-seeded				
A 488	1744	593	1151	-
Ancash 66 (C)	1641	1242	399	683
A 489	1556	1639	-83	481
A 482	890	738	152	542
Group mean	740	430		462
Small, white-seeded				
BAC 125	1700	813	887	788
BAT 1469	1351	542	809	839
Group mean	1209	472		680
Bush materials for the South Pacific countries (group 40000)				
BAT 1417	1387	775	612	794
EMP 106	1330	1029	301	828
BAT 1544	1325	826	499	621
Group mean	941	416		486

(Continued)

Table 2. (Continued)

Line	Popayan: With chemical protection	Popayan: Without chemical protection	Difference	Palmira: Without chemical protection
Bush materials for the Mexican highlands (group 40500)				
A 445	1786	1574	212	686
A 414	1614	866	748	677
A 410	1121	819	302	758
Group mean	1014	731		620
Small, cream-seeded				
A 321	2198	1147	1051	936
A 375	2189	1382	807	952
A 386	2072	1538	534	-
BAT 1458	1660	1100	560	-
EMP 117	1562	1134	428	-
A 242	1500	1053	447	847
A 262	1486	1058	428	-
A 358	1380	910	470	1019
A 315	1330	1023	307	1009
A 176 (C)	1284	1048	236	878
A 301	1268	1010	258	-
A 243	1252	909	343	-
A 297	1236	823	413	945
A 259	1220	781	439	-
A 344	1203	797	406	-
Group mean	1143	779		811

International Bean Yield and Adaptation Nursery

1982 IBYAN

A total of 42 bush and 24 climbing bean lines were selected from the 1981 EP for the 1982 IBYAN, however, a large number of previous EP entries were continued in the IBYAN trials.

The characteristics, composition number of entries and distribution pattern for the 1982 IBYAN are shown in Table 3.

This report includes results of the 1982 IBYAN trials planted in Colombia and a summary of the 1981 trials in all sites where the IBYAN was planted.

Table 3. Characteristics, composition and number of entries for the 1982 IBYAN.

Type of trials	Growth habit	Grain characteristics		Entries (no.)	Distribution				
		Color	Size		Latin America	Africa	Asia	Others	Total
IBYAN 10000	Bush	Black	Small	14	57 (100)[a]	-	-	-	57
IBYAN 20000	Bush	Red	Small	10	38 (83)	2 (8)	-	4 (9)	44
IBYAN 20500	Bush	Red	Med/large	12	36 (56)	23 (36)	1 (2)	4 (6)	64
IBYAN 30000	Bush	White	Small	10	5 (62)	1 (13)	-	2 (25)	8
IBYAN 50000	Bush	Cream/brown	Small	14	26 (52)	13 (26)	2 (4)	9 (18)	50
IBYAN 60000	Climbing	Black	Small	10	15 (100)	-	-	-	15
IBYAN 70000	Climbing	Red	Small/med	10	26 (76)	8 (24)	-	-	34
IBYAN 80000	Climbing	Light colors	Med/large	10	7 (58)	5 (42)	-	-	12

a. Numbers in parentheses indicate percentage distributed in that area.

Bush beans

Four types of trials, based on grain characteristics, were planted at CIAT-Palmira and CIAT-Popayan. Each trial was formed by a set of new breeding lines or varieties derived from the EP, and three types of checks: elite (chosen from the best material from the preceding IBYAN); international (long-term checks chosen among varieties known for their stability); and local (furnished by the cooperator).

The trials at CIAT-Palmira were conducted without chemical disease control whereas those of CIAT-Popayan were conducted under both chemically protected and non-protected conditions.

The results for the 1982B semester at Palmira and Popayan are presented comparing the best new breeding lines against their checks.

Tables 4-7 show the average yields of the black-seeded, small red, large reds, small whites, and small cream-seeded lines at both Palmira and Popayan sites.

With few exceptions, particularly in the small seeded beans, in the three other groups the rank of the best and worst lines was similar under chemically protected and non-protected conditions at Popayan. In two groups (except in the small red and the black seeded group) some lines performed similarly at both CIAT and Popayan, indicating progress in the development of materials with wide adaptation. Among the small reds, A 21, BAC 36 and Copan were the lines that behaved well at these two contrasting sites (Table 5). Among the cream-seeded lines, A 286 and A 140 showed high yields and wide adaptation (Table 7).

At both sites the new black-seeded lines (Table 4) showed a net superiority in yield over outstanding checks like Jamapa, Porrillo Sintético, and BAT 58. BAT 304, one of the elite checks, and BAT 527, a former IBYAN entry used as local check, continued to show outstanding performance under non-protected conditions in Popayán.

Among small reds (Table 5) there is a good number of outstanding new materials. Under non-protected conditions at Popayan, the local and elite checks were outperformed by the red materials selected by the Costa Rican and Honduran programs from a base population provided by CIAT.

Climbing beans

Among the black-seeded lines, V 8025, V 8030, and V 8020 were the ones that showed best performance. None of the lines tested outperformed the local checks among the red-seeded group although V 7920-12 appeared to be as good as the very well known check Rojo 70. G 3410 clearly outperformed varieties ICA Viboral and Liborino among the cream-seeded group. These trials were conducted at Popayan (Table 8).

Table 4. Average yield of the new black-seeded breeding lines and checks tested in the 1982 IBYAN at CIAT-Palmira and Popayan. 1981 semester A.

Palmira			Popayan (with chemical protection)			Popayan (without chemical protection)		
Rank	Identification	Yield (kg/ha)	Rank	Identification	Yield (kg/ha)	Rank	Identification	Yield (kg/ha)
New breeding materials (n = 18)								
1	DOR 62	1458	1	BAC 78	3427	2	BAC 78	2099
2	EMP 84	1418	3	BAC 25	3228	4	BAT 1191	1917
5	A 235	1124	4	EMP 60	2889	5	BAC 25	1880
Checks (n = 6)								
3	BAT 59 (E)[a]	1337	2	BAT 304 (E)	3326	1	BAT 527 (L)	2629
4	BAT 271 (L)	1168	6	ICA Pijao (L)	2836	3	BAT 304 (E)	1989
8	Porrillo (I) Sintético	1028	9	Jamapa (I)	2875	12	Jamapa (I)	1607
Mean (n = 14)		1087			2847			1799
$LSD_{.05}$		438			364			291
Range		627			1048			1589
C.V. (%)		24			7.2			9.6

a. n = number of entries in the group
I = international check
E = elite check
L = local check

Table 5. Average yield of the new small, red-seeded breeding lines and checks tested in the 1981 IBYAN at CIAT-Palmira and Popayan. 1982 semester A.

	Palmira		Popayan (with chemical protection)		Popayan (without chemical protection)	
Rank	Identification	Yield (kg/ha)	Identification	Yield (kg/ha)	Identification	Yield (kg/ha)
1	A 21 (E)[a]	1592	BAC 36	3107	Chorotega	2378
2	Copan	1352	BAT 1192	2749	Corobici	2358
3	BAC 36	1337	Chorotega	2738	Copan	2224
4	Chorotega	1124	A 21 (E)	2660	BAC 36	2170
5	Corobici	1096	Corobici	2507	A 21 (E)	2100
6	A 40 (L)	1076	BAT 1217	2465	BAT 1191	2045
Mean (n = 9)		1150		2581		2056
$LSD_{.05}$		365		456		344
C.V. (%)		18.3		10.2		9.7

a. n = number of entries in the group.
E = elite check
L = local check

Table 6. Average yield of the new small, white-seeded breeding lines and checks tested in the 1982 IBYAN at CIAT-*Palmira* and Popayan. 1982 semester A.

Palmira			Popayan (with chemical protection)			Popayan (without chemical protection)		
Rank	Identification	Yield (kg/ha)	Rank	Identification	Yield (kg/ha)	Rank	Identification	Yield (kg/ha)
New breeding materials								
1	BAC 43	1273	1	BAT 1147	2483	1	A 182	1864
3	BAT 1276	1166	2	A 182	2209	2	Línea 23	1714
4	BAT 1254	1165	3	BAT 1253	1713	3	BAC 43	1670
5	BAT 1272	1145	4	BAC 43	1579	4	BAT 1253	1584
Checks								
2	Línea 24 (E)[a]	1189	5	Diacol Calima (L)	1577	10	Diacol Calima (L)	1203
9	Diacol Calima (L)	999	9	Línea 24	1374	11	Línea 24 (E)	1068
Mean (n = 12)		1004			1590			1373
$LSD_{.05}$		211			378			593
Range		856			1433			969
C.V. (%)		12.4			14			25.5

a. n = number of entries in the group.
E = elite check.
L = local check.

Table 7. Average yield of the new cream-seeded breeding lines and checks tested in the 1981 IBYAN at CIAT-Palmira and Popayan. 1982 semester A.

	Palmira		Popayan (with chemical protection)		Popayan (without chemical protection)	
Rank	Identification	Yield (kg/ha)	Identification	Yield (kg/ha)	Identification	Yield (kg/ha)
Five best breeding lines						
1	A 140	1886	A 86	3325	A 154	2666
2	A 286	1856	A 176	3279	A 286	2534
3	BAT 477	1822	A 156	3238	A 79	2496
4	EMP 86	1799	BAC 65	3187	A 59	2434
5	BAT 85	1688	A 286	3129	A 140	2433
Lowest yielding breeding lines						
17	A 162	1247	A 59	2640	A 162	1892
18	G 5054	1138	A 163	2328	BAC 68	1877
19	A 156	1062	EMP 86	2286	A 163	1686
20	A 336	1050	A 162	2075	EMP 86	1656
Mean (n = 20)[a]		1495		2850		2143
$LSD_{.05}$		479		645		536
Range		838		1230		1010
C.V. (%)		19.4		13.7		15.1

a. n = number of entries in the group.

Table 8. Average yield of the five best lines tested in the 1982 VIRAF trials at Popayan. 1982 semester A.

	Black-seeded		Red-seeded		Light colors/large seeds	
Rank	Identification	Yield (kg/ha)	Identification	Yield (kg/ha)	Identification	Yield (kg/ha)
1	V 8025	1492	Ecuador 299	1600	G 3410	3063
2	V 8030	1465	V 7920-12	1249	Calabozo	2557
3	V 8020	1321	Rojo 70	1126	G 12488	2393
4	P 16 (L)[a]	1118	V 7004-1-12	989	ICA Viboral	2335
5	V 7982	1055	BAT 1217	620	Liborino voluble	2196
Mean (n = 10)[a]		1042		797		1879
$LSD_{.05}$		299		281		401
Range		1267		1218		2842
C.V. (%)		16.7		20.5		12.4

a. n = number of entries in the group.
L = local check.

1980 IBYAN trials

Last year's annual report presented only data from Palmira and Popayan sites for the 1980 IBYAN trials, the same as is being done now for 1982. Complete results of the international bean yield trial are published in a separate report, however, a brief summary is given here. Table 9 shows the mean yield of the five types of bush bean trials across locations. ICTA-Tamazulapa, BAT 1289, BAT 1297, Ex Rico 23 and BAT 561 were the best within their respective group, although in general most lines gave yields as high as those of the best elite and international checks. In most places the best local check was outperformed by the best experimental line (Table 10). Superiority of the new breeding lines, as shown for black beans in the Dominican Republic, small reds in Costa Rica, large reds in Haiti, and creams in Zimbabwe, was dramatic, whereas in cases where the local entries outyielded the best experimental lines, differences always were small and only in one instance--Greece-- reached 29%.

Table 9. Average yields of the bush breeding lines tested in the 1981 IBYAN.

Rank	Experimental lines	Yield (kg/ha)	Experimental lines	Yield (kg/ha)
Black-seeded lines (based on data from 26 sites)			Cream-seeded lines (based on data from 11 sites)	
1	ICTA Tamazulapa	1881 a[a]	BAT 561	2324 a[a]
2	BAT 804[b]	1820 ab	A 83	2283 a
3	BAT 873[b]	1802 ab	A 81	2170 a
4	BAT 1060	1794 ab	Carioca	2153 a
5	BAT 527	1780 ab	IAPAR-RAI-54	2133 a
6	BAT 832	1776 ab	BAT 874	2127 a
7	Jamapa	1730 ab	CENA 164-1	2115 a
8	BAT 304[b]	1680 ab	A 80[c]	2067 a
9	BAT 58[b]	1631 b	A 90	2014 a
10	Porrillo Sintético	1588 b		
	Mean	1749		2154
	C.V. (%)	17.8		15.2
Small red-seeded lines (based on data from 10 sites)			Large-medium red-seeded lines (based on data from 19 sites)	
1	BAT 1289	1427 a[a]	BAT 1297[d]	1758 a[a]
2	A 21	1419 a	BAT 1296[d]	1701 a
3	BAT 37	1305 ab	BAT 1230[d]	1616 ab
4	BAT 1293	1246 ab	Línea 23	1603 ab
5	BAT 1235	1179 ab	Línea 22	1582 ab
6	BAT 41	1112 b	Línea 24	1455 b
7	BAT 1155	1056 b		
	Mean	1249		1614
	C.V. (%)	19.6		18.0
White-seeded lines (based on data from 8 sites)				
1	Ex Rico 23[e]	2507 a[a]		
2	BAT 1198	2297 ab		
3	78-0374	2282 ab		
4	BAT 1281	2212 abc		
5	BAT 1257	2198 abc		
6	BAT 1061	2075 abc		
7	BAT 1280	1939 bc		
8	BAC 38	1837 c		
	Mean	2161		
	C.V. (%)	22.1		

a. Duncan's multiple range test, .05 level.
b. 21 sites.
c. 9 sites.
d. 16 sites.
e. 7 sites.

Table 10. Performance of outstanding lines relative to the best local check. 1981 IBYAN.

Country	Site	Best: Experimental lines (EL)[a]	Best: Local check (LC)[a]	LC vs. EL: % above	LC vs. EL: % below
Black-seeded lines					
Brazil	Vicosa B	BAT 804	BAT 65	0.7	
Colombia	Popayan B	BAT 527	A 229	10.3	
El Salvador	San Andrés B	EMP 84	Porrillo 70	6.2	
Mexico	Santiago Ixcuintla	Jamapa	Negro Nayarit	12.9	
Argentina	Misiones	BAT 832	Rico 23		25.9
	Monte Redondo	A 232	DOR 41		11.3
	Trancas	BAT 832	DOR 41		1.0
	Rosario de la Fontera	A 218	Testigo Local No. 1		0.2
Brasil	Vicosa A	BAT 873	BAT 64		24.4
	Campos B	Porrillo Sintético	Moruna		4.4
Colombia	Palmira B	BAC 25	A 232		14.2
Costa Rica	Alajuela A	BAT 304	Pavamor		12.5
Cuba	Alquizar	ICTA Tamazulapa	Bolita 42		6.8
Chile	Graneros	BAT 58	L 6080		15.0
	Graneros	EMP 84	Negro Argel		10.4
	Chillán	EMP 84	Negro Argel		4.5
Dominican Republic	San Juan de la Maguana	BAC 78	BAT 271		33.7
El Salvador	San Andrés B	ICTA Tamazulapa	S 184 N		29.9
Mexico	Isla, Ver.	BAT 58	Negro Veracruz		7.4
	Huastecas B	Jamapa	Delicias 71		1.7
Peru	Cañete A	BAC 25	Testigo Local No. 2		18.8
Venezuela	Maracay A	BAT 48	Cubagua		33.0
	Acarigua	BAT 1060	Testigo Local 1		11.4
	Maracay A	BAT 873	Coche		9.6
	Maracay B	BAT 804	Coche		1.6
	Saman Mocho A	Porrillo Sintético	Coche		0.6

(Continued)

Table 10. (Continued)

Country	Site	Best: Experimental lines (EL)[a]	Best: Local check (LC)[a]	LC vs. EL: % above	LC vs. EL: % below
Small, red-seeded					
Honduras	Catacamas B	BAT 1289	Cincuenteño	9.5	
Colombia	Palmira B	BAT 1289	BAT 1230		15.7
	Popayan B	A 21	BAT 795		2.0
Costa Rica	Alajuela B	BAT 37	Mexico 80		32.5
Cuba	Alquizar	BAT 1293	CC-25-9		3.5
El Salvador	San Andrés B	BAT 41	MCS 97 R		23.0
	San Andrés	BAT 1289	Arbolito Retinto		10.9
Honduras	Jamastran B	BAT 1289	Honduras 46		17.9
	Zamorano	A 21	Honduras 46		7.7
Large, red-mottled seed					
Burundi	Mosso	BAT 1297	Karama	5.8	
Cameroon	Dschang	Línea 22	Porrillo	24.5	
Chile	Chillán	BAT 1296	Araucano INIA	11.8	
Rwanda	Rwerere	Línea 23	Tostado	1.7	
South Africa	Delmas	BAT 1296	Bonus	14.6	
Zaire	Mulungu	Línea 24	Myagosi 35	0.1	
Colombia	Palestina B	BAT 1230	Calima		29.1
	Palmira B	Línea 22	ICA Palmar		10.1
Cuba	Alquizar	Línea 23	M-112		25.4
Chile	Graneros	BAT 1297	Small Red Rufus		0.5
Haiti	Saint Raphael	BAT 1275	Salagnac 86		61.0
Jamaica	Kingston	Línea 24	Miss Kelly		97.7
Mauritus	Beau Bassin	BAT 1297	Local Red		27.0
Peru	Mollepata	Línea 22	Red Kidney		49.5
	La Molina B	BAT 1296	Redkloud		14.0

(Continued)

Table 10. (Continued)

Country	Site	Best: Experimental lines (EL)[a]	Best: Local check (LC)[a]	LC vs. EL: % above	LC vs. EL: % below
Rwanda	Rubona	BAT 1297	Tostado		17.5
	Karama	BAT 1297	Bataaf		0.2
Thailand	Chiang Mai	BAT 1249	Avalanche		79.0
Zimbabwe	Harare	BAT 1296	Red Canadian Wonder		58.7
White-seeded					
Cuba	Alquizar	BAT 1061	BAT 482	0.7	
Chile	Santiago	78-0374	Testigo Local 2	4.1	
	Graneros	Ex Rico 23	D 76035	0.9	
Greece	Pyrgetos	78-0374	OE-35	29.4	
Colombia	Popayan B	BAT 1281	A 43		23.4
	Palmira B	BAT 1281	A 43		16.0
Chile	Graneros	BAT 1061	L 7580		9.4
South Africa	Delmas	BAT 1198	Bonus		10.3
Cream-seeded					
Brazil	Selviria B	A 90	Carioca	1.3	
Colombia	Popayan B	A 286	A 286	3.4	
Argentina	Misiones	IAPAR RAI 54	Carioca		20.3
Bolivia	Santa Cruz	BAT 874	CENA 164-2		22.7
Brazil	Ponte Nova	BAT 561	V.I. 1010		19.6
	Lavras	BAT 874	Rio IVAI		14.9
Colombia	Palmira B	A 90	A 286		4.0
Chile	Graneros	BAT 160	Tortola Diana		25.5
	Graneros	A 83	BAT 85		3.8
South Africa	Delmas	IAPAR RAI 54	Bonus		5.1
Zimbabwe	Harare	BAT 561	Line 193		68.7

a. EL = experimental line; LC = local check.

19816

19816

Evaluation and Improvement of Agronomic Practices

The Effect of Maize-Bean Association on Bean Insects

In the 1981 Annual Report some preliminary results of maize-bean association on *Empoasca kraemeri* were presented, and it was demonstrated that *E. kraemeri* numbers were lower in association than in monoculture beans. The following is a more complete report of effects of this crop association on *E. kraemeri* populations as well as on other bean insects.

Population levels of *Diabrotica* spp. were higher in association than in bean monoculture (Figure 1). The higher population levels of *Diabrotica* in association were probably due to the attraction of this insect to maize.

In the 1981 Annual Report it was suggested that lower levels of *E. kraemeri* in association were probably not attributable to increased action of natural enemies. Further studies in 1982 showed that, instead, higher levels of parasitism of eggs of *E. kraemeri* by *Anagrus* sp. occurred in association than in bean monoculture (Figure 2). However, at the same time there was higher percentage of unhatched *E. kraemeri* eggs in the monoculture than in association (Figure 3). The physical appearance of maize may have acted as a deterrent, or, at least, not as a stimulant, to colonizing individuals of *E. kraemeri*.

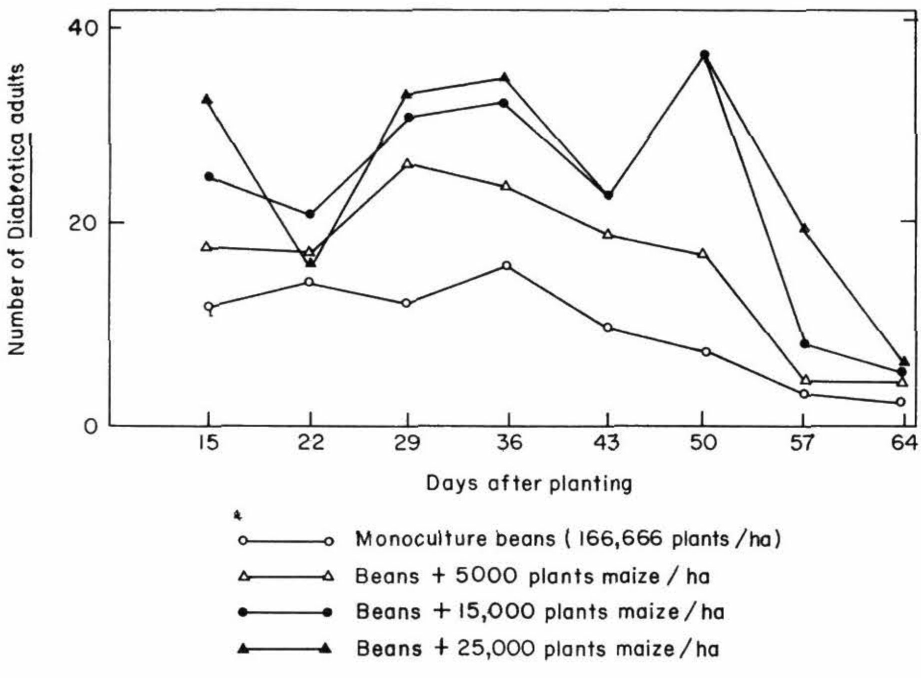


Figure 1. Number of adults of *Diabrotica* collected with a D-Vac in monoculture beans and beans intercropped with maize.

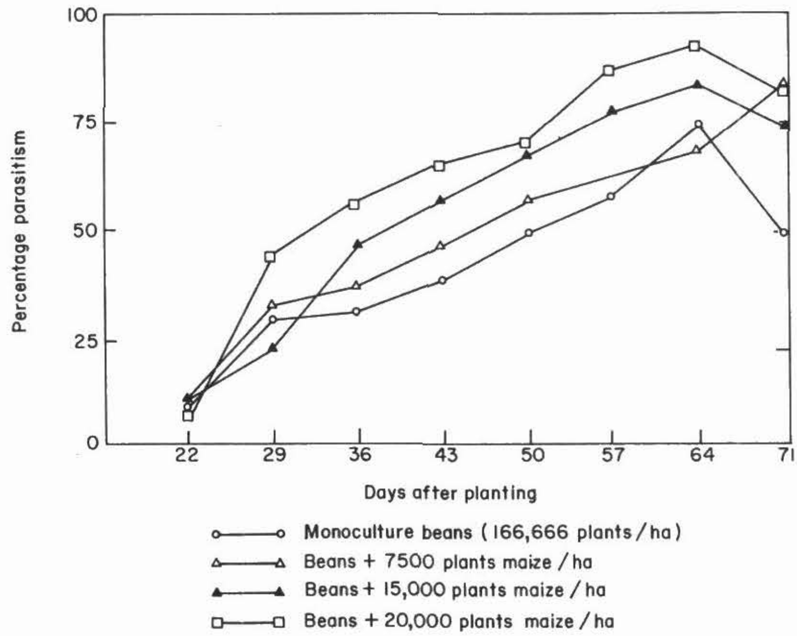


Figure 2. Percentage parasitism of eggs of E. kraemeri by *Anagrus* sp. in monoculture beans and beans intercropped with maize.

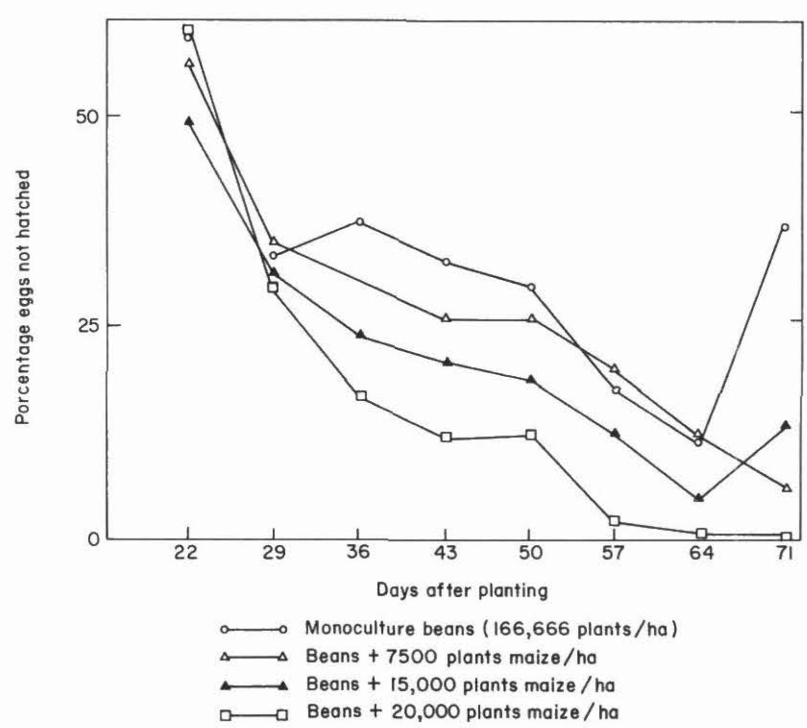


Figure 3. Percentage of eggs of E. kraemeri not hatched in monoculture beans and beans intercropped with maize.

19817

Evaluation of Herbicides in Beans and Maize - Beans

Based on the work carried out in 1981B in La Selva, Obonuco, CIAT-Popayán, and CIAT-Palmira, a group of herbicides was selected to control weeds in bean plantings. The selection of these products was based on their weed control efficiency and index of damage caused to beans.

The individual performance of these products was evaluated in CIAT-Palmira using the recommended and a higher application rate. The safety range of the herbicides was also evaluated using eight different bean varieties varying in seed color and size.

Results obtained for the best treatments are presented in Tables 1 and 2.

The combination of these herbicides was evaluated according to the type of weeds that each controls. These trials could not be completed due to the strong rains and flooding which damaged the beans.

Until the flood occurred (± 25 days), the mixtures Afalón 2 kg/ha + Prowl 4 lt/ha, Patorán 2.5 kg/ha + Prowl 4 lt/ha, Afalón 2 kg/ha + Dual 3 lt/ha, and Surflán 2.5 kg/ha + Afalón 2 kg/ha showed selectivity for the three crops used in the trial (bush bean variety BAT 41; climbing bean variety Magdalena 3; and maize variety Swan 1).

Based on the theory of possible protective effect of the herbicides belonging to the denitroaniline group against damage caused by beans by herbicides belonging to the group of substituted ureas, three trials were carried out which did not bear this out; results indicated also that herbicides Sencor, Gesagard and Gobexo cannot be used in beans under CIAT-Palmira conditions.

Cuadro 1. Herbicides that control weeds best and are less toxic to beans under CIAT-Palmira conditions.

Treatment	Rate (kg ai/ha)	Damage index		Overall control (%)		Bean yield (kg/ha)
		15 days	30 days	15 days	30 days	
Surflán	1.5	1.5	1.4	96	76	1193
Surflán	2.25	1.6	1.4	96	86	1280
Afalón	1.2	1.5	1.7	96	77	1108
Afalón	1.6	2.1	1.8	96	78	1084
Prowl	1.0	1.6	1.3	90	40	1080
Prowl	2.0	1.5	1.3	95	38	1207
Dual	1.9	1.5	1.2	90	17	1226
Dual	3.8	1.7	1.4	93	52	1103
Control	-	1.6	1.5	0	0	947

Table 2. General control aspects of the best herbicides for CIAT-Palmira (see Table 1).

Herbicide	Does not control	Reduces competition
Surflán	Cyperus spp. Ipomoea spp.	Emilia sonchifolia
Afalón	Grasses Cyperus spp. Ipomoea spp.	Malvaceae
Prowl	Ipomoea spp. Emilia sonchifolia	Cyperus spp.
Dual	Broad leaf weeds	Amaranthus spp. Portulaca oleracea

As a partial result of these trials, two Prowl based mixtures were found safe for beans (BAT 448 black and BAT 785 red) and showed high relative yields: Afalón 1.5 kg/ha + Prowl 4 lt/ha, and Patorán 2.5 kg/ha + Prowl 4 lt/ha.

Another aspect studied was the use of postemergent herbicides and their effect on both weeds and beans. The results are shown in Table 3.

The effect of Gramoxone and Roundup was also studied using the surfactants Triton Act, Agral 90, Cida Kick and Herbex in applications directed to already established and flowering weeds. Triton Act at 0.5% concentration was the most active surfactant in mixture with Gramoxone. Roundup performed similarly when applied alone or in mixture with some of the surfactants used.

Due to damages caused by Atrazine residuality on bean crops at CIAT, a trial was carried out in which visible damages in two bean varieties could be observed up to 150 days after its application (Table 4).

In a trial that was carried out during the dry season there were no significantly different responses in terms of damage to beans between the chemical treatments Afalón 2 kg/ha, Afalón 3 kg/ha, and Afalón 1.5 kg/ha + Dual 2 kg/ha. The contrary was observed for Atrazine treatments with a positive response to a rate increase of the product, showing residuality symptoms 180 days after its application (Table 5).

Table 3. General aspects of postemergent herbicides for beans.

Herbicide	Control	Safety
HOE 00581[a]	Excellent control of grasses at any age	Total
Basagrán	Good control of broad leaf seedlings	Intermediate
Blazer	Good overall control of seedlings	Low-none

a. Experimental product.

Table 4. Damage ratings in beans (15 days after germination) due to Atrazine residuality.

Material	Atrazine (kg ai/ha)	Damage index after application 120 days	150 days	180 days	210 days
I	4.0	4.0	4.0	3.0	1.0
C	3.0	2.9	2.2	2.7	1.0
A	2.0	2.6	2.5	3.0	1.0
L					
24	Control	1.4	1.5	2.7	2.0
P	4.0	5.5	4.2	1.5	1.0
	3.0	4.0	2.5	1.2	1.0
5 6	2.0	2.5	1.7	1.7	1.0
6					
	Control	2.1	1.2	1.2	1.0

Table 5. Damage index in beans 120, 150, and 180 days after Atrazine applications using preemergent herbicide treatments at planting.

Atrazine (kg/ha)	Preemergent treatment (kg/ha)	Damage index		
		120[a]	150[a]	180[a]
4.0	Afalón 2.0	7.5	6.2	3.7
	Afalón 3.0	8.2	6.5	3.7
	Afalón 1.5 + Dual 2.0	7.0	6.2	3.7
	No treatment	6.0	6.2	3.0
3.0	Afalón 2.0	6.5	5.5	2.2
	Afalón 3.0	5.5	4.2	3.2
	Afalón 1.5 + Dual 2.0	5.1	5.0	2.2
	No treatment	4.1	5.7	1.7
2.0	Afalón 2.0	2.4	3.5	1.5
	Afalón 3.0	3.2	4.5	2.0
	Afalón 1.5 + Dual 2.0	3.2	3.5	2.0
	No treatment	4.1	3.5	1.0
Control	Afalón 2.0	1.4	2.0	2.0
	Afalón 3.0	1.0	2.2	2.2
	Afalón 1.5 + Dual 2.0	1.1	1.7	1.7
	No treatment	1.2	2.0	2.0

a. Days of bean planting after Atrazine treatment.

La Selva Station (ICA-Rionegro)

The location of La Selva station facilitates weed control research in soils with high organic matter content representative of the agroclimatic conditions of eastern Antioquia. Weed control was investigated for three basic conditions:

a. Preparation of soils used for maize-climbing beans relay systems through postemergence control of weeds before bean planting.

b. Preemergence control of weeds in monoculture and association systems.

c. Utilization of postemergent herbicides in bush bean, maize, and climbing bean crops.

Overall control as well as control of individual species of weeds typical of the zone (*Ambrosia artemissifolia* L., *Poligonum segetum* H.B.K., *Galinsoga ciliata* (Raf.) Blake, *Cyperus* spp. and grasses in general) were evaluated.

A trial was carried out for the maize-climbing bean relay system which consisted in controlling weeds at the time of relay, that is, when the climbing beans were planted next to the maize stalks (Table 6). Following the methodology used in overall weed control trials in bush bean and climbing beans x maize systems in Palmira, two trials were done; the first one in 1981B and the second one in 1982A. Table 7 presents results of the best treatments from the first trial.

Table 6. Herbicide mixtures that could be used in maize-climbing bean relay systems.

Treatment	Time of application[b]	Rate (kg/ai/ha)	Overall control (%)[a]	
			35 days	65 days
Dual + Roundup	Post	5.8 + 1.45	96.5	92
NC 20484 + Roundup	Post	3.2 + 1.45	94.5	95
Dual + Lazo + Gramoxone	Post	3.8 + 1.0 + 1.5	94.5	89.5
NC 20484 + Gramoxone	Post	3.2 + 0.5	94.5	86.2
Dual + Gramoxone	Post	5.8 + 0.5	90.8	82.5
Roundup	Post	1.4	90.0	66.6
Gramoxone	Post	0.5	82.5	48.3
Absolute control		-	15.0	5.0

a. Mean of four replications.
b. Postemergent application relative to weeds and preemergent application relative to climbing beans.

Table 7. Results of preliminary trial on overall weed control in monoculture beans and maize-climbing bean association systems at La Selva, 1981B.

Treatment	Time of application	Rate (kg/ai/ha)	Overall control (%)		
			20 days	60 days	90 days
Dual	PRE	4.8	70	84	56
Preforán	PRE	4.8	60	75	57
NC 20484	PRE	2.0	80	80	49
Afalón	PRE	1.4	23	70	56
Surflán	PRE	2.25	10	57	54
Lazo	PRE	1.45	46	56	32
Prowl	PRE	1.3	27	50	36
Control	-	-	5	5	15

Based on results of the previous trial, an experiment was done during 1982A with the products presented in Table 7 applied alone or in mixtures (Table 8). Given the importance of studying postemergent herbicides for both the crop and the weeds, Table 9 shows results obtained with Basagrán and HOE 00581 under the agroecological conditions of the zone. The aggressiveness of species such as G. ciliata, P. segetum, and the prevailing grasses in the area causes a strong invasion of any of them when the balance is broken through the application of a product specific to any of the other species.

Table 8. Promising herbicide mixtures to control weeds in bush bean monoculture and maize-climbing bean association systems at La Selva, 1982A.

Treatment	Time of application	Rate (kg/ai/ha)	Overall control (%) 30 days	Overall control (%) 60 days
NC 20484 + Dual	PRE	1.2 + 2.9	89	37
NC 20484 + Gesagard	PRE	1.2 + 1.25	80	42
NC 20484 + Afalón	PRE	1.2 + 1.4	82	20
Afalón + Dual	PRE	1.4 + 2.9	76	40
Surflán + Gesagard	PRE	1.9 + 1.25	77	28
Control	-	-	5	0

Table 9. Performance of two postemergent herbicides in bush beans, climbing beans, and maize at La Selva, 1982A.

Treatment	Rate (kg CP/ha)	Damage index: Bush beans	Damage index: Climbing beans	Damage index: Maize	Does not control
Basagrán	3.0	2	1	1	Grasses Galinsoga ciliata
HOE 00581	2.5	1	1	10	Poligonum segetum[a]
Basagrán + HOE 00581	1.5 + 1.5	1	1	10	Galinsoga ciliata

a. HOE 00581 at a high rate (3.0 kg CP/ha) reduces the population of Galinsoga ciliata but not the low rate (1.5 kg CP/ha).

CIAT-Popayan Station

The acid and low fertility conditions of CIAT-Popayan soils served to carry out a trial on weed control in bush bean monoculture and maize-climbing bean association systems (Table 10).

A trial with postemergent herbicides, the same utilized in La Selva, applied to both weeds and crops, was also carried out in the aforementioned cropping systems, the results of which are similar to those presented in Table 9.

The residual effect of Atrazine under CIAT-Popayan conditions was evaluated in bean materials G 7908 (climbing beans) and BAT 448 (bush beans). Results showed that 30 days after the application of Atrazine at a rate of 3.5 kg/ha there was no evidence of residuality based on visual damage assessments.

Obonuco Station (ICA-Pasto)

As in La Selva and Popayan, a preliminary trial on overall weed control was carried out in Obonuco in 1981B. Results presented in Table 11 show that Surflân and NC 20484 are the best herbicides for overall weed control in monoculture beans and climbing bean-maize association systems.

Table 10. Results of the best treatments to control weeds in monoculture bush beans and maize-climbing bean association systems at Popayan, 1982A.

Treatment	Time of application	Rate (kg/ai/ha)	Overall control (%) 20 days	Overall control (%) 50 days
Gesagard	PRE	1.75	85	80
Afalón	PRE	1.9	77	72
Surflân + Afalón	PRE	1.9 + 1.0	77	65
Prowl + Gesagard	PRE	1.3 + 1.25	75	67
NC 20484 + Afalón	PRE	1.2 + 1.4	70	72
Lazo	PRE	2.9	82	57
Surflân + Gesagard	PRE	1.9 + 1.25	75	60
Afalón + Dual	PRE	1.0 + 2.9	62	72
Dual	PRE		67	52
Control	-	-		5

Table 11. Results of preliminary trial on weed control in monoculture bush beans and maize-climbing beans in association at Obonuco, 1981B.

Treatment	Time of application	Rate (kg/ai/ha)	Overall control (%)	
			40 days	60 days
Surflán	PRE	2.5	77	60
NC 20484	PRE	2.0	76	59
Afalón + Dual	PRE	1.0 + 2.0	70	51
Afalón	PRE	1.5	70	49
Modown	PRE	2.0	72	32
Dual	PRE	4.0	57	36
Control	-	-	20	25

19818

Effect of Calcium x Phosphorus Interaction in Beans

Two experiments were carried out in CIAT-Popayan (1850 masl, 1900 mm average annual rainfall, and 17.5°C average annual temperature) to measure the calcium x phosphorus interaction in bean varieties Carioca and ICA-Tui. The soils had the following characteristics: pH: 5.0; OM%: 34; Bray II available P_2O_5: 1.2 ppm; K: 2.7 meq/100 g; Ca: 1.4 meq/100 g; Mg: 0.50 meq/100 g; Al: 2.0 meq/100 g. The treatments included five $CaCO_3$ levels as dolomitic lime: 0, 500, 1000, 2000, and 4000 kg/ha and six P levels as triple superphosphate applied in bands to the bottom of the furrow: 22, 44, 88, 176, 352, and 704 kg/ha.

Two planting were made and only the first one received the treatments; the second one was planted to measure the residual effect of the treatments.

In the first harvest, the high average yields of Carioca were 2146 kg/ha (14% moisture content) with 704 kg P/ha + 200 kg dolomitic lime/ha; ICA-Tui also produced its highest average yield of 1820 kg/ha with the same treatment. Carioca showed a better response and a higher resistance to anthracnose and ascochyta leaf spot.

The highest average yield for both varieties of 2137 kg/ha was obtained with 2790 kg dolomitic lime/ha and 515 kg P/ha as triple superphosphate. The response of both varieties to the application of P and Ca was highly significant; there was no Ca x P interaction in either the first or second trial (Tables 1 and 2).

Figures 1, 2, and 3 show the bean yields obtained with the different levels of lime and phosphorus. From an economic point of view, not of maximum yields, it can be observed that an average yield of 1154 kg/ha is obtained when 66-132 kg P/ha are applied at any lime level and 1546 kg/ha with 132-264 kg P/ha as triple superphosphate at any lime level. When less than 66 kg P/ha are applied, average yields ranged between 762 and 369 kg/ha at any lime level.

In the second harvest, in which the residual effect was measured, performance of the two bean varieties was similar to that of the first harvest (Figures 1, 2, and 3).

For Carioca, the highest yield of 2142 kg/ha was obtained with 704 kg P/ha + 2000 kg dolomitic lime/ha; for ICA-Tui, the highest yield of 690 kg/ha was obtained with the same treatment.

For both bean varieties, an average yield of 764 kg/ha was obtained from the residual effect of the application of 66-132 kg P/ha and 1064 kg/ha with 132-264 kg P/ha at any lime level. With P levels under 66 kg/ha, bean yields ranged between 164 and 464 kg/ha. A similar trend was observed in the first harvest indicating good residual effect, especially for Carioca.

It can be concluded that for CIAT-Popayan conditions in new soils, bean yields of approximately 1 t/ha are obtained with the application of 66-132 kg P/ha as triple superphosphate and 1 t dolomitic lime/ha (mostly to neutralize Al).

This recommendation can be followed to support at least two consecutive bean harvests, although yields are reduced in the second harvest, especially in the case of materials less tolerant to low soil P such as ICA-Tui.

Table 1. Regressión deviation for bean yield at 14% humidity, first harvest.

Parameter	Degrees of freedom	Mean square	Probability
Calcium	3	1588041	0.0002[a]
Phosphorus	3	19759184	0.0001[a]
Calcium x phosphorus	1	4050171	0.7409[b]

a. High significant response (1%).
b. Non-significant response.

Table 2. Bean materials efficient at low phosphorus and responding to phosphate fertilization. Yield in kg/ha and at 14% humidity.

Materials	Unstressed	P stress	Alfa
Carioca	1763	1696	0.26898
A 444	1869	1622	0.98551
A 295	1782	1566	0.86493
A 283	1582	1498	0.33485
A 244	1838	1455	1.53252
Aete 3	1736	1426	1.23790
Catu	1630	1409	0.88360
A 445	1785	1367	1.67301
Average of quadrant	1748	1505	0.97266

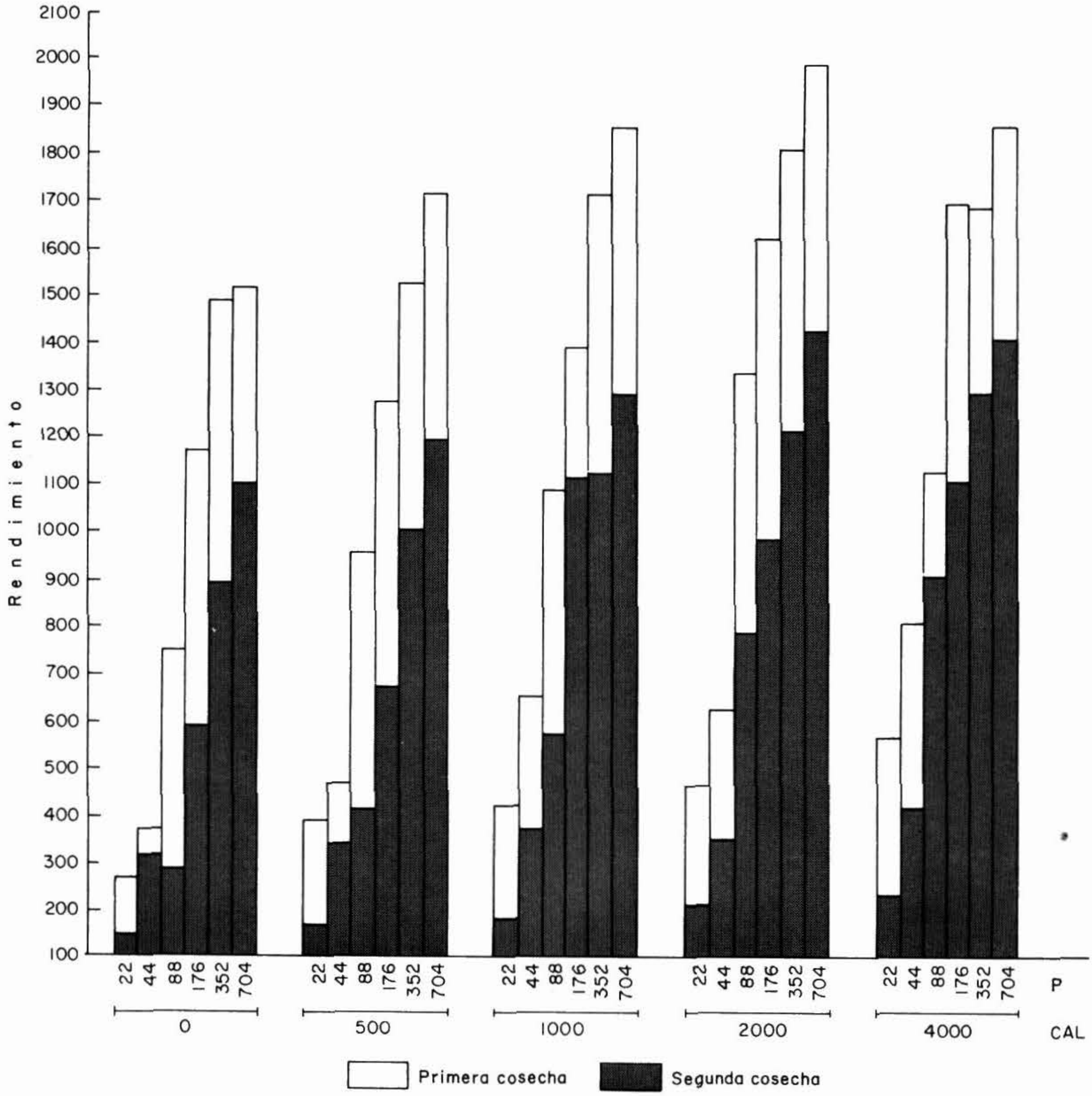


Figure 1. Effects of different phosphorus and dolomitic lime levels on bean yields of two consecutive harvests.

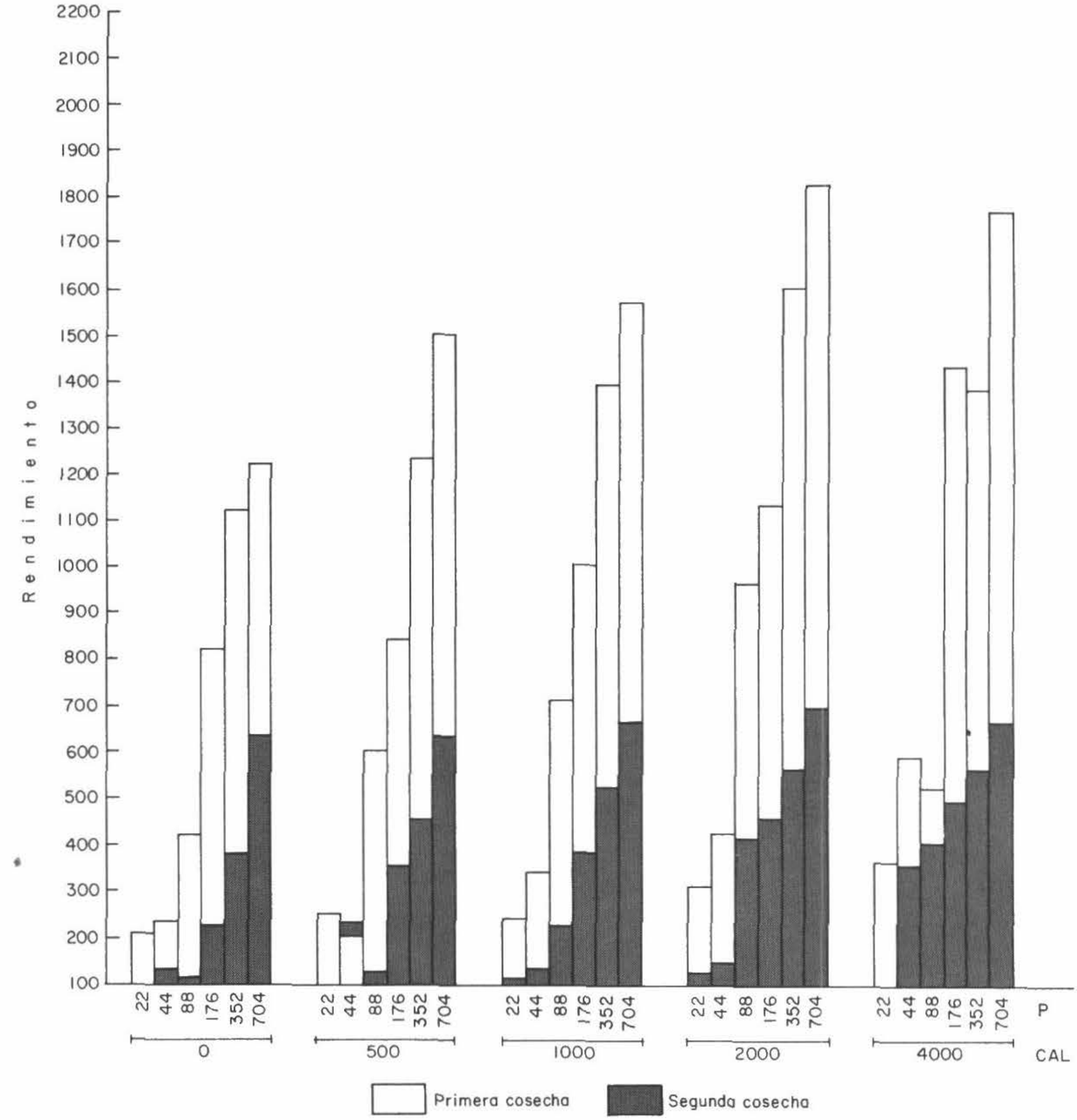


Figure 2. Effects of different phosphorus and dolomitic lime levels on yields of bean variety ICA-Tui in two consecutive harvests.

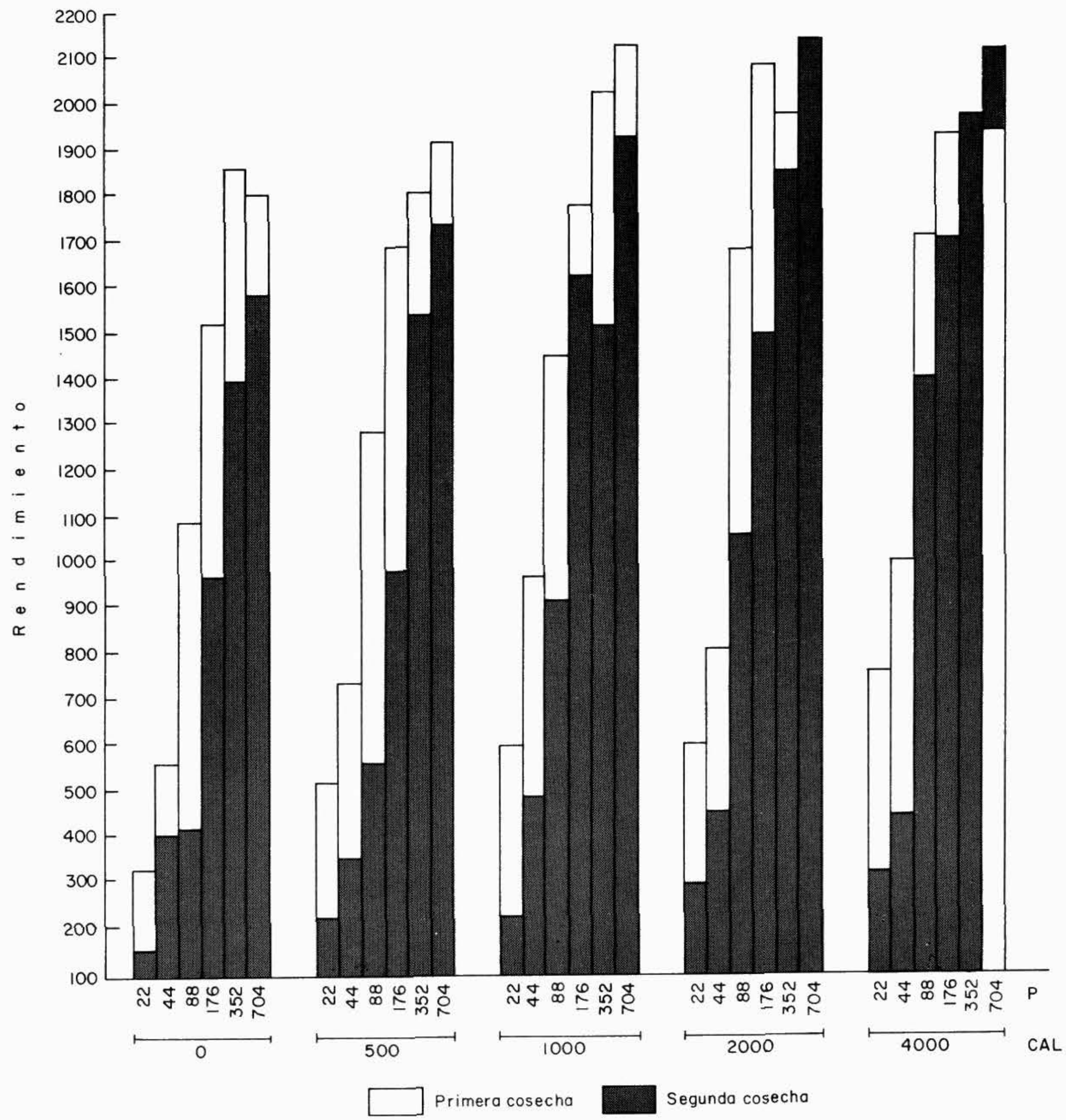


Figure 3. Effects of different phosphorus and dolomitic lime levels on yields (average of two consecutive harvests) of bean variety Carioca.

19819

Alternative Phosphorous Sources

During the first eight months of the year agronomic research activities concentrated in final testing for residual effects of triple superphosphate (TSP), finely ground PR, partially acidulated PR and TSP extended with PR, methods of application and varietal response of common beans to P sources and mixtures in a Typic dystrandept from Popayan, very high in P fixation and in an Orthoxic palehumult from CIAT-Quilichao, using beans as test crop.

Residual Effects and Methods of Application

A very important factor which must be considered in the determination of the suitability of the P sources is the residual value. Unlike the mobile nutrients, P remains in the vicinity of application for long periods of time and remains available to provide a portion of the crop's requirements for a number of cropping periods. Previous experiments established in Las Guacas, Popayan, showed that the highly reactive PRs were equal or better than TSP in providing residually available P in each of the three subsequent semesters following the initial cropping period. The medium and low reactivity PRs tended to increase in effectiveness until they became equal or very close (82%) to residual TSP in the third crop. In order to determine (a) the relative effectiveness of Huila PR on an Andept with a higher P retention capacity than that of Las Guacas, (b) if mixtures of PR with varying proportions of TSP or partially acidulated PR would serve to supply the initial plant requirements for water-soluble P, and (c) to evaluate methods of application, experiments were established with beans in CIAT-Popayan station for the first time during 1981A. Results of the first harvest were discussed in the 1981 Annual Report. The second and third harvests with reapplications of the initial P rates (Figures 1, 2, and 3) still are showing that the relative agronomic effectiveness (RAE) of Huila PR, when broadcast and incorporated, is less than 50% as effective as soluble P, except when low P rates are used. For the third crop of beans, Figure 2, an application of 44 kg P/ha as TSP produces almost equal yields as 176 kg P/ha applied as finely ground Huila PR. This agrees with the results discussed in the 1981 Annual Report, that a reduction in effectiveness of PRs is observed on Andepts which exhibit higher P retention and higher reactive Al than Ultisols and Oxisols.

For the first crop of beans (Annual Report 1981), the method of application greatly influences the effectiveness of the Huila PR (Figure 1). Band application resulted in yields with an RAE of 40% as effective as broadcast and incorporated. In the case of the first crop this reduction in yield potential from PRs may be very important for small farmers that apply fertilizers with a localized placement technique, but it could become unimportant if residual effect is considered (Figure 2), because the yield differences between broadcast and band PR applications practically disappear for the second and third crops. Possibly, the first and second application of banded PR was uniformly incorporated to the soil during soil preparation, and the residual effect of this later incorporated PR compensated for the yield reduction due to band application of PR for the third crop.

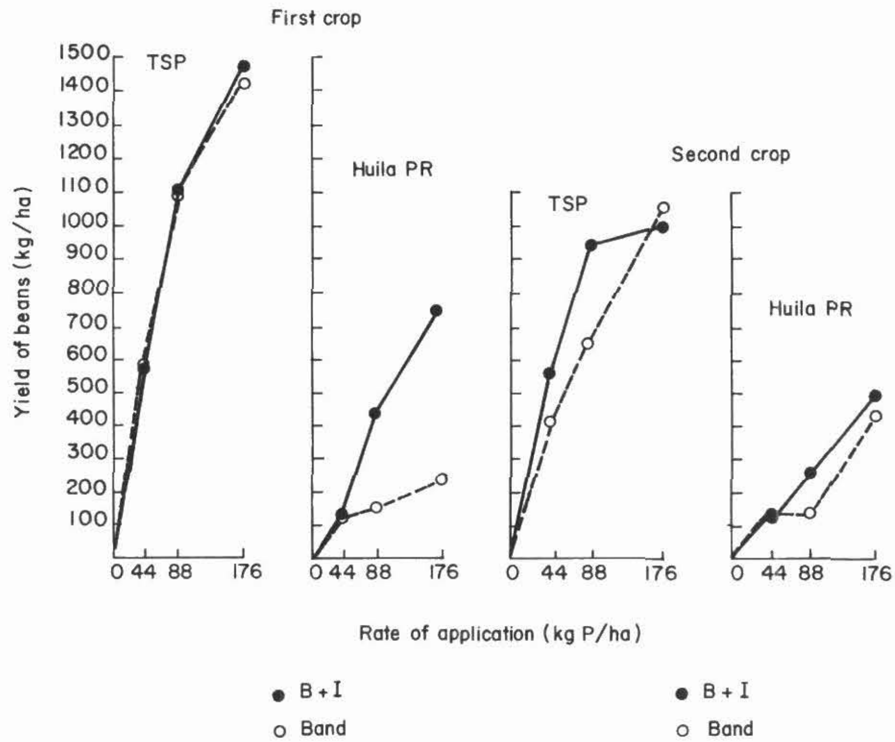


Figure 1. Residual effect of TSO and Huila PR on the production of beans on an Andosol from CIAT-Popayan. The P sources were broadcast and incorporated (B + I) or banded.

In the case of TSP, for the first crop, nearly identical response curves were observed regardless of the method of application (Annual Report 1981). For the second and third crops (Figures 1 and 2), yields were generally higher when TSP was broadcast and incorporated than when the water soluble fertilizer was band applied. This confirms that the potential advantage of reduced contact with the soil by using localized placement is not of great importance in these soils probably due to the fact that broadcast TSP increased the volume of soil from which P could be extracted. Once several P applications have been made, and the available P in the soil has increased, then band applications of TSP can be a better practice than broadcast applications (Figure 3).

Residual effect of management of mixtures of TSP and PRs

An experiment to evaluate the effectiveness of mixtures of TSP and Huila PR and the management of these mixtures was initiated during the first semester of 1981, using G 4000 beans as a test crop. Two more crops were planted in the same plots during 1981B and 1982A semesters.

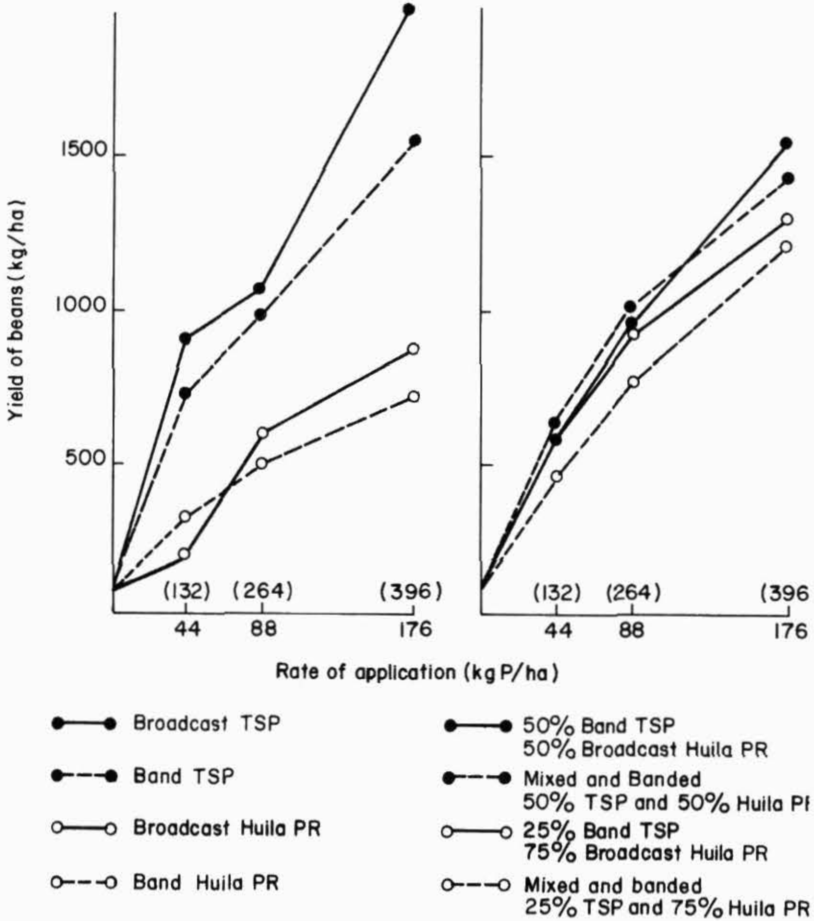


Figure 2. Response of beans (G 4000) as affected by source, rate, method of application and residual effect (CIAT-Popayan 1982A). Numbers in parenthesis represent total P applied to the soil for three crops.

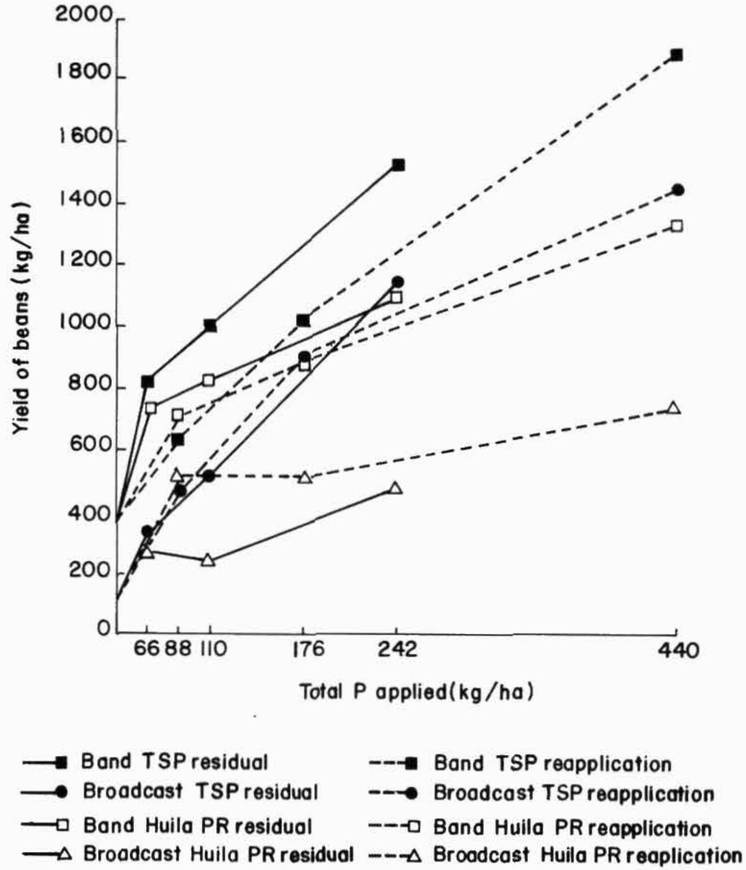


Figure 3. Response of beans (G 4000) as affected by source, rate, method of application and reapplication of 44 kg P/ha as banded TSP or broadcast Huila PR. Third crop 1982A. All band applications + 44 kg P/ha as banded TSP; all broadcast applications + 44 kg P/ha as broadcast Huila PR.

Reapplications of the initial P sources, rates and mixtures were performed for these two new crops. Results of the first experiment indicate that the response of the beans to added P was systematically reduced as the proportion of TSP in the mixture was reduced. In the case of the second and third harvests (Figure 2), TSP alone was generally better than the mixtures, but mixtures of 50% TSP banded and 50% Huila PR broadcast and incorporated produced almost equal yields to the 25% TSP-75% Huila PR mixture. This was not the case when the TSP and the PR were mixed and band applied. These results confirm that after three crops the major portion of the applied P utilized by the plant was still provided by the water soluble P carrier. In general, yields of the third crop were higher than those of the first and second crops, indicating that the P fertility of the soil is showing significant improvement due to the presence of both the TSP and the lower cost indigenous material.

Modified indigenous PRs and its residual effect

Partial acidulation of PR in varying proportions with either H_2SO_4 or H_3PO_4 increased initial plant-available P. For this reason, partially acidulated Pesca PR, 20 and 40%, with H_2SO_4, and cogranulated mixtures of Pesca PR with 18% and 9% TSP, have been tested. Table 1 shows the water and citrate soluble P of the different products. In an experiment conducted in CIAT-Popayan during the second semester of 1981 and the first semester of 1982, the effectiveness of partially acidulated Pesca PR and mixtures of TSP and Pesca PR and the residual effect was evaluated with G 4000 beans. It can be observed in Figure 4a that the partial acidulation of the PR to 40% produces similar yields to TSP at rates of 44, 88, and 176 kg P/ha. Cogranulation (18% to TSP) produces yields almost equal to partially acidulated Pesca PR (40%) at 352 kg P/ha rate. At all P rates, yields decreased as the water and citrate solubility of the P decreased, and similar yields were obtained with partially acidulated Pesca PR (20%) and cogranules of Pesca PR with

Table 1. Solubility of modified Pesca phosphate rock.

Source	Modification	H_2O sol. P, (%)	Citrate sol. P (%)	H_2O + citrate sol. P (%)
Pesca PR	Finely ground	0.0	2.9	2.9
	20% PA (H_2SO_4)	18.2	21.8	40.0
	40% PP (H_2SO_4)	57.1	19.4	76.5
	Cogranulated 9% TSP	11.2	21.5	32.7
	Cogranulated 18% TSP	22.6	22.7	45.3

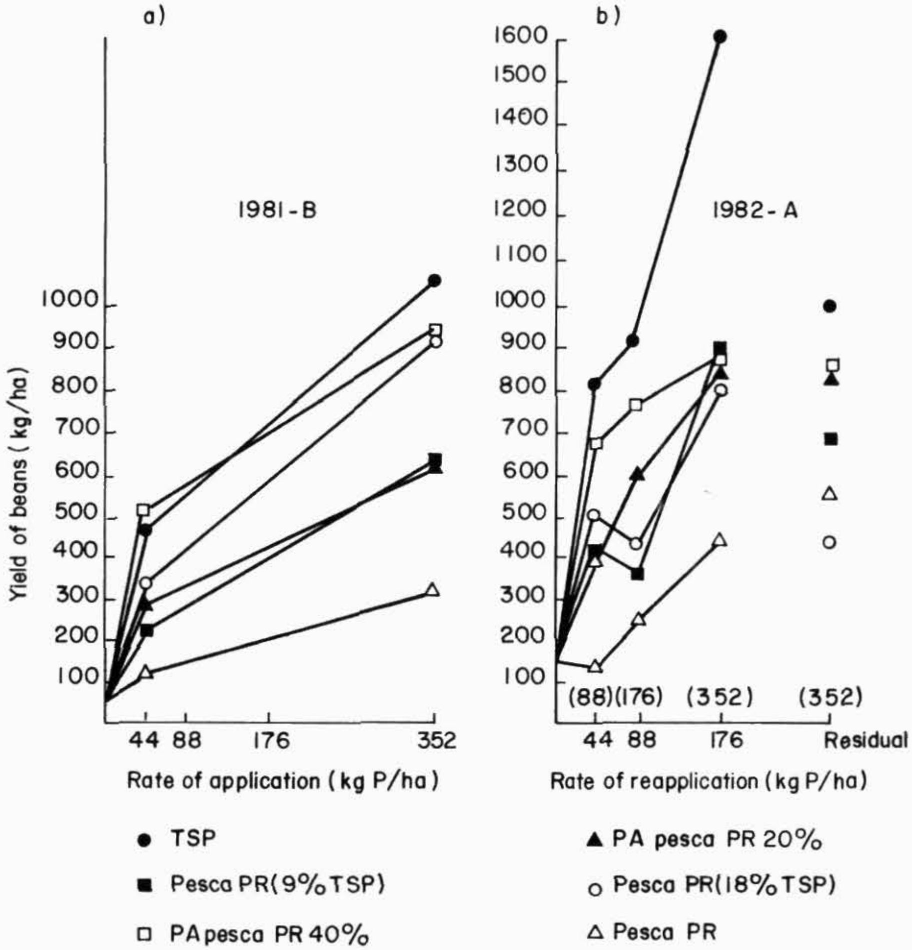


Figure 4. Effect of partial acidulation and cogranulation of TSP with Pesca PR on the production of beans on an Andept from CIAT-Popayan. Numbers in parenthesis represent total P applied for the two crops.

9% TSP. During the first semester of 1982, this experiment was repeated in the same plots with reapplication of the same P sources at rates of 44, 88, and 176 kg P/ha. Plots that had received 352 kg P/ha during the first crop were planted but no additional P was added in order to see the residual effect of the different P sources. Figure 4b shows the results of the second harvest. In this case, reapplication of soluble P sources resulted in better yields than those of low P solubility. When high P rates were reapplied (176 kg P/ha) there were no yield differences among the Pesca PR modified products. Apparently the yield increase was due to the soluble P present in each of the products tested, because the response of beans to residual P showed yield differences among the P sources producing higher yields for those with high soluble P like TSP and partially acidulated Pesca PR, 40 and 20%.

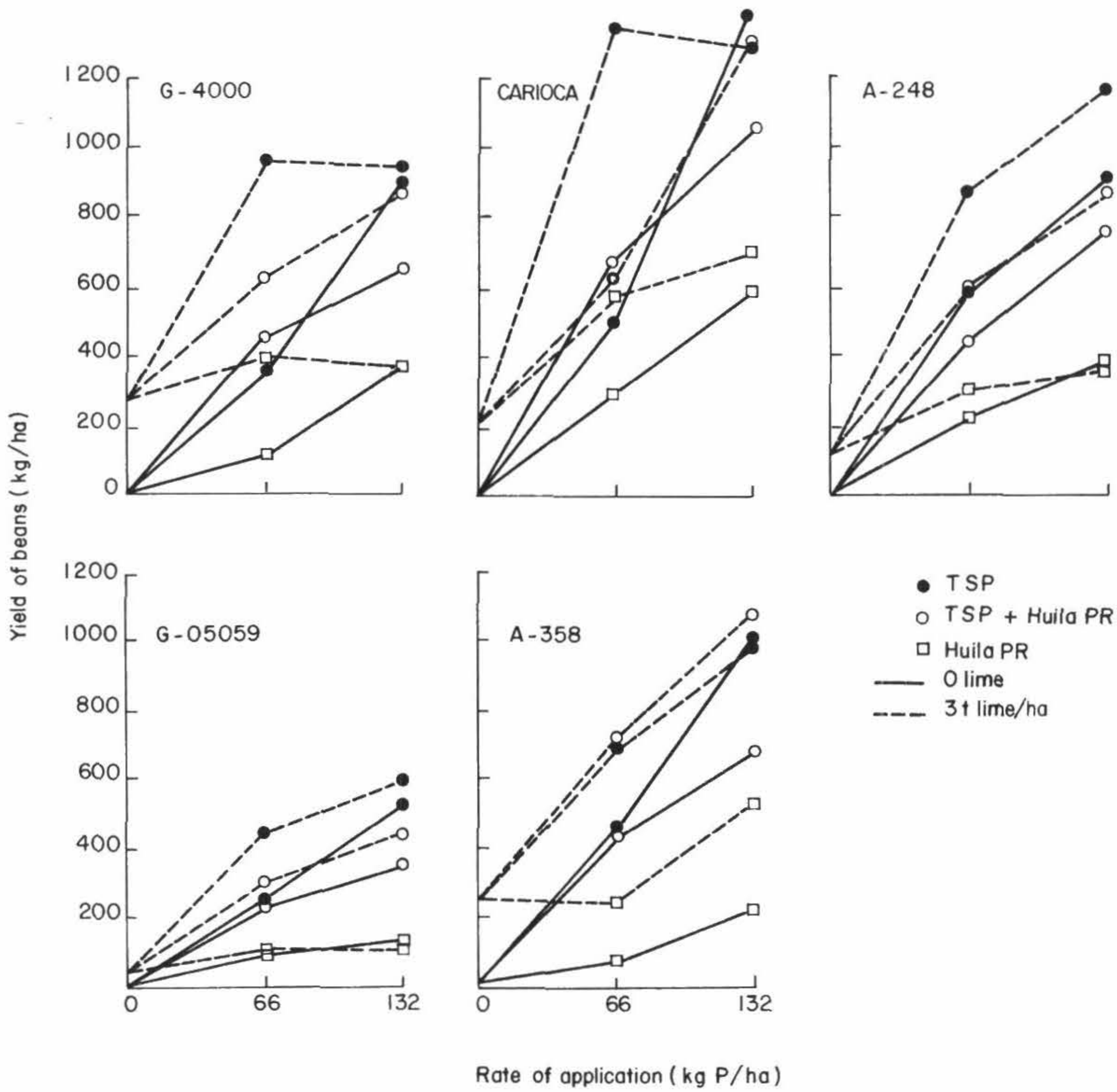


Figure 5. Effect of P rates, sources and liming on yield of five bean varieties grown on a CIAT-Popayan Andept.

Figure 4b also shows a good residual effect of finely ground Pesca PR. Yield increase of residual 352 kg P/ha, applied as Pesca PR, was 120 kg of beans/ha, if 115 kg of beans/ha representing the increase of the check plot are subtracted from the yield obtained for this treatment. It is also interesting to observe that when Pesca PR or partially acidulated Pesca PR was used, one single application to the first crop or two applications of half of the same P rate to each crop produces equal yields for the second crop. A yield decrease was observed for the residual P treatment of 352 kg P/ha when TSP was used, showing the effect of the high P fixation capacity of the soil.

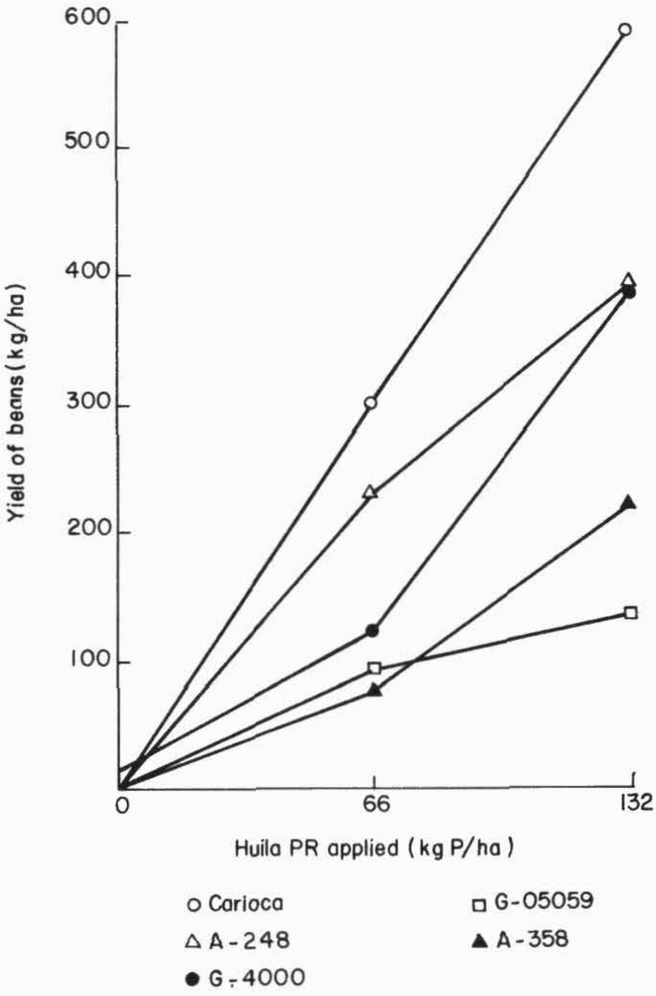


Figure 6. Response of five bean varieties to applications of Huila PR. CIAT-Popayan Andept.

Differential response of bean varieties to P sources and lime

In order to investigate (a) if differences exist among varieties in their relative efficiency in use of P from sources of low P solubility; (b) to determine the need for soluble P in a soil with high P fixation capacity; and (c) to investigate the soluble P/lime interaction, an experiment was established on a CIAT-Popayan Andept during the first semester of 1982. Although variation in the yield of beans among replications was relatively high it is interesting to analyze some of the results obtained. Figure 5 shows the response of the five bean varieties tested to P rates applied as TSP, Huila PR and a mixture of 50% P as TSP and 50% as Huila PR. The results obtained indicate that in general there was a differential response among the varieties to applied P. The best responses were obtained with Carioca, followed by A 248, G 4000 and A 358. The variety G 05059 presented the lowest response to P fertilization and also yields in the check plots were very low. As in other experiments on this soil, relative agronomic effectiveness of the P sources followed the order: TSP > TSP + Huila PR > Huila PR, but when the rate of P applied was only 66 kg/ha, the mixture of TSP and PR produced yields equal to TSP alone. Figure 6 shows that a differential response was obtained of the varieties to Huila PR applications. In this case, varieties Carioca, A 248 and G 4000 presented a good response to Huila PR when compared with varieties A 358 and G 05059.

In general, the application of 3 t of lime/ha produced a yield increase when no P was added, but this increase was higher for the varieties G 4000, A 358, and Carioca. Lime also increased the response to P except when a soluble P source was used at a high rate. Varieties that responded to liming did not show yield increase when lime and Huila PR are used together, if these treatments are compared with the yield obtained with the Huila PR alone. Probably the application of 132 kg P/ha as Huila PR (1500 kg Huila PR/ha), that is very high in free $CaCO_3$, is sufficient to provide the Ca demand of four of the varieties tested, and to neutralize some of the exchange acidity of the soil. It is possible also that the Ca concentration due to liming was high enough to restrict the dissolution of the PR due to common ion effect. With varieties like G 4000 and A 358 yields were better using 3 t lime/ha than 750 kg Huila PR/ha. In the case of varieties that only present slight responses to lime, apparently it is better to use Huila PR alone instead of lime without P, or the combination of lime and Huila PR.

19820

19820

On Farm Research

Active national programs for beans now exist in most countries of Latin America. CIAT research support and scientific training has played an important role in strengthening many of them. New bean varieties are available as a result, as discussed elsewhere in this report. With notable exceptions, there are problems in many countries in the transfer of these varieties to the small farmer and in the design of cultural practices to accompany them. An increasing body of experience (Gilbert, Norman, and Winch, 1980; IRRI, 1981; Norman, Simmons, and Hays, 1982) suggests that these practices should be designed and information about varietal needs fed back to breeding programs from work in the farmer's own conditions, using as a base his cropping systems and management practices. Although the recommendations to farmers and the trials used to derive them may vary from region to region, it should be possible to design methodologies for on-farm research and technology transfer in beans which are useful in all regions. The Bean Program's activity in on-farm research is intended to fill a need identified in the adaptation of methodologies to systems where more than one crop is present and in their divulgation to bean researchers and extensionists.

In addition, on-farm research feeds back information to varietal improvement programs on the likely success of the breeding strategies being pursued, especially that of producing varieties with high levels of disease and insect resistance and relatively low input requirements. Included also is the responsibility of identifying from results in farmers' fields, factors which have not received adequate attention in varietal improvement.

Adaptation of Methodology

A methodology for on-farm research and technology transfer (Figure 1) based on those used by CIMMYT (Barnett, 1982) and by ICTA Guatemala (Waugh, 1981) is being tested in collaboration with ICA, the national research and extension service of Colombia (Woolley, in press). This continues the work on methodologies of on-farm technology evaluation carried out since 1977 in the bean and cassava programs of CIAT (Sanders and Lynam, 1982). The areas in which on-farm research is being conducted, three in Nariño and one in Antioquia, cover four different agroclimatic zones. In each, small farmers use a different cropping system for beans (Table 1 and Tables 6 and 7 in Economics section). The areas also provide contrasts in the level of technology used by farmers and the amount of previous research on beans. On-farm research in beans has been suspended in southern Huila since 1980 (see Economics section). Nariño has both the bush bean systems represented in southern Huila and in addition the highland system of maize and beans in direct association. This is very attractive for logistic reasons.

Work being initiated by the Central American Regional Project in collaboration with CATIE and national programs will provide information

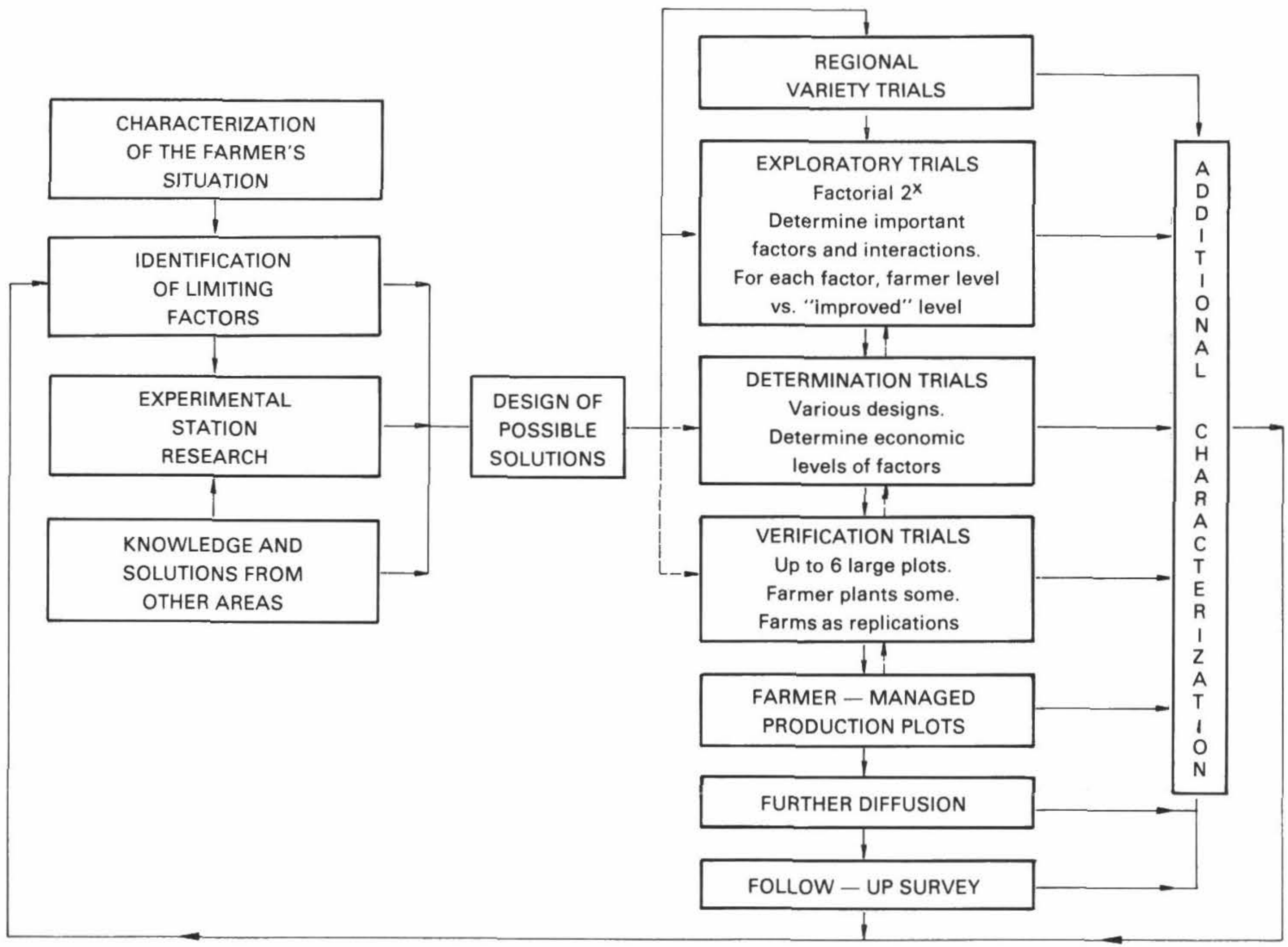


Figure 1. A methodology for reseach and technology transfer.

Table 1. Principal features of areas in which bean on-farm research is conducted in Colombia.

	Eastern Antioquia	Southern Nariño	Central Nariño	Northern Nariño
Altitude (m)	2000-2300	2400-2900	1800-2300	900-1500
Principal bean systems	Relay intercropping with maize	Association with maize[a]	Monoculture	Row intercropping with maize
Bean type	Climbing	Climbing	Bush	Bush and semi-climbing
Principal planting months for beans	April-October (becoming more variable)	August-October	October, March	October, March
Length of bean cycle (months)	5-6	8-9	4-5	3-4
Principal rotation crops	Potato (every 2 years)	Potato Barley	Peas	No rotation
		Farmer Bean Practices		
Fumigating (%)	100	93	75	3
Number of fumigations	6.8	4.3	2.2	-
Using chemical fertilizer (%)	94	62	40	20
Using seed treatment (%)	32	24	0	3

a. Broad beans and cucurbits commonly present as well.

from an important system not represented in Colombia, bush and semi-climbing beans in relay with maize in the subtropics.

The key to the methodology (Figure 1) is the characterization of the farmers' situation by both informal and formal techniques. From this, production constraints are identified in the cropping system being studied and are used, with the results of component research carried out at experimental stations and the solutions obtained in other regions, to design farm trials.

In the regional variety trials, one or two varieties are identified for comparison with the traditional variety in later stages. The exploratory trials check the previous diagnosis of important limiting factors and identify those which need to be studied together because of their interactions. Economic levels of these factors or groups of factors are then identified in the determination trials with each factor present at three or more levels. A range of the most promising technologies identified in the previous stages is compared in large plots with the farmer's technology, planted by him, in the verification trials. The most suitable technology for each type of farmer is then tested by many farmers under the guidance of the research worker and extensionist in farmer-managed production plots, opening the way to mass transfer of technology and a follow-up survey to measure adoption. Major responsibility for the on-farm research activities passes from the research worker in the early stages to the extensionist in the later stages, but both take part in all the steps.

Within the methodology three strategies are being tested. In southern Nariño several steps have been initiated simultaneously with most emphasis placed on regional variety trials and exploratory trials. Only a few determination trials and verification trials have been designed, using "informed guesses" about the factors likely to be found important and suitable technologies. This strategy is illustrated by the flow lines in Figure 1. In central and northern Nariño the strategy is similar but no verification trials have been planted. In subsequent years in all three zones of Nariño, the proportion of trials devoted to the later steps will increase.

In Antioquia, previous research means that work may be concentrated mostly in the determination and verification phases, while on-farm regional variety trials continue to identify promising new varieties.

Twenty verification trials including the new variety ICA Llanogrande and the traditional variety of each location, each tested at three different technology levels, have been distributed to areas where no previous on-farm research on beans has been carried out. One objective is to determine whether this type of rapid promotion of a new variety with technologies extrapolated from a different region may succeed. If some technologies in the verification trials are successful, on-farm research may proceed both towards more verification trials and farmer managed production plots and also return to earlier stages of the research process to fine-tune the extrapolated technology and identify other limiting factors. This strategy represents a reversal in the order of the steps in Figure 1 and is similar to that used by IRRI (1981) for rice based-systems in Asia.

Feedback of Information to CIAT

Since the main planting season in all the agroclimatic zones in 1982 was from August to October, only limited experimental results are available at the time of writing. A series of preliminary trials was conducted in the first, less important season in northern and central Nariño at the same time as the characterization to aid diagnosis and design of the second season's trials. The first season, from March to June/July is particularly prone to poor rainfall distribution and in 1982 there were problems both of waterlogging soon after planting and of a drought of more than one month before and during flowering. Empoasca attack was generally severe but disease pressure was light. Yield levels were low but should be viewed against a background of complete crop loss in the two areas for a majority of farmers.

With the exception of BAT 1274, all the BAT lines tested with medium-sized red-mottled seed yielded well and showed less severe disease attack than Limoneño the most commonly used local variety (Table 2). BAT 1235 was slightly more stable and high yielding than BAT 1230 and BAT 1297 and has been chosen for comparison with Limoneño under different agronomic inputs in 1982B. ICA Llanogrande and Ancash 66, which are of IVa and IIIb habits at higher altitudes, showed little tendency to climb and yielded surprisingly well at these altitudes (1400-1500 m) but were later than the BAT lines.

Table 2. Regional variety trial. Northern Nariño 1982A. Beans row intercropped with maize.

Variety	Yield (kg/ha)				Principal diseases observed[b]
	Site 1[a]	Site 2[a]	Site 3[a]	Mean	
BAT 1235	689	652	1527	956	ALS
Ancash	933	764	1150	949	None
ICA Llanogrande	832	694	1233	920	WBT
BAT 1230	628	583	1458	890	ALS
BAT 1297	524	750	1350	875	ALS
Diacol Catio	602	486	1319	802	ALS BAC WBT
Argentino (farmer check)	728	583	902	738	None
A 470	511	555	1041	702	ANT
Limoneño (farmer check)	575	763	722	687	ANT
Diacol Calima	485	416	972	624	ANT ALS WBT CMV
BAT 1274	451	305	652	469	WBT
LSD (5%)	214	pending			

Other materials tested (intermediate between Limoneño and BAT 1274): ICA Lines 22, 23, and 24, Diacol Nima, A 469.

a. Site identification: 1 = Granada, Taminango (mean maize yield 1736 kg/ha); 2 = Las Cochas, El Tambo; 3 = San Francisco, El Tambo.
b. ALS = angular leaf spot; WBT = web blight; ANT = anthracnose; BAC = bacteriosis; CMV = bean common mosaic virus.

A regional variety trial for monoculture in central Nariño was not sufficiently uniform to obtain yield data but, from disease and vigor ratings, Ancash 66 appeared the best adapted. This, and results from an area of similar altitude in eastern Antioquia, led to the choice of this variety for trials in 1982B in central Nariño.

Two exploratory trials were lost due to waterlogging followed by drought and Empoasca attack and the design of a third had to be modified (eliminating the factor density) in order to analyze the results. Those which did reach harvest indicated that, while Limoneño and BAT 1235 yielded the same without fertilization, only BAT 1235 responded positively to its presence (Table 3). BAT 1235 was also two weeks earlier to maturity than Limoneño. In the very poor fertility soils (P = 2.5 ppm) and drought conditions of the site in northern Nariño, there was also a positive response to density in fertilized BAT 1235. Foliar disease control with benomyl had no effect at either site as would be expected in the dry conditions prevailing from 40 days after planting.

In a trial to examine the use of soil insecticides and different planting densities, carbofuran was found to give the most effective control. An achieved plant density of $22/m^2$ appeared marginally superior to the farmers' density of $11/m^2$ although this difference did not achieve statistical significance (Table 4).

Because of the preliminary nature and limited number of these trials conducted in the minor growing season it would be inappropriate to highlight them as a source of information to the varietal improvement program. Information feedback from the newly researched areas in Nariño will increase in February 1983 when the first of the 1982B trials are harvested. The potential of BAT 1235 for medium altitude zones was, however, indicated and included an acceptable tolerance of low phosphorus conditions, although more drought resistance would be desirable. Greater seed size in such lines of Andean grain type for medium altitude is desirable to obtain high consumer acceptance in Colombia; progress for this character is being made in varietal improvement efforts. The fertilizer responsiveness of BAT 1235 in comparison to Limoneño is an advantage for the small farmer, provided, as was the case here, the fertilizer-responsive line yields at least the same as the local variety when no fertilizer is applied. The high risk of drought in northern Nariño makes farmers cautious in fertilizer adoption, although even in this year of quite severe drought, this farmer would have made a small profit on fertilizer application in BAT 1235, provided he had used a higher seed rate than normal so as to establish 22 plants/m^2.

A number of plant habits have been identified in seed lots classed under the name Limoneño. The type grown in this area was vigorous when adapted and had a desirable IIB plant habit. It was immediately incorporated in the crossing program to increase its disease resistance, tolerance to drought and tolerance to low phosphorus.

Table 3. Exploratory trial on variety, disease control, fertilizer use and density. 1982A. Yield (kg/ha).

Variety	Northern Nariño (row intercropped with maize)				Central Nariño (monoculture)	
	Without fertilizer		200 kg/ha 13-26-6		Without fertilizer	200 kg/ha 13-26-6
	11 plants/m^2	22 plants/m^2	11 plants/m^2	22 plants/m^2	28 plants/m^2	28 plants/m^2
Limoneño	6	26	4	92	247	262
BAT 1235	12	76	162	330	298	586
LSD (5%)		174			175	

Yield of farmer-managed check (Limoneño) in both locations = 0.

Table 4. Seed treatment and planting density trial. Central Nariño 1982A. Monoculture.

$Plants/m^2$	No control	Aldrin (liquid) 0.35 kg/ha	Carbofuran 1 kg/ha	Mean
11	274	517	529	440
22	388	422	662	491
33	361	340	440	380
Mean	341	426	544	
LSD (5%)	262 (individual treatments)			
	152 (means)			

In eastern Antioquia a regional variety trial of 28 lines was conducted in monoculture on stakes at four sites outside the normal planting season to permit the identification of the most promising new line for testing in the 1982B season with Cargamanto (the local variety), ICA Viboral and ICA Llanogrande, together with different cultural practices.

Yield data from two sites were lost due to early harvest by the farmer but the visual ratings of vigor which had been taken agreed with the other high yielding site (Marinilla) with little disease incidence (Maneb was applied twice by the farmer). The fourth site (El Carmen) suffered severe fertility problems and estimated varietal performance in poor conditions, although with a high coefficient of variation. No disease control was practiced at this site.

The two lines of highest mean yield (Table 5) did not have the most preferred seed type for eastern Antioquia, but are of great interest for other areas. The line ICA La Selva 1 had high and stable yield, preferred seed type and acceptable resistance to the principal diseases of the area; it was selected for use in the 1982B trials. Among other lines of high resistance and acceptable yield and seed color were some of early maturity such as V 5793-38, V 5761-32-35, and V 6785-325. Twenty-four of the lines are being retested in 1982B in relay with maize to confirm these preliminary results.

The potential of the new BAT lines for medium altitude zones of Colombia was clearly shown by a thesis project in Caicedonia, Valle department (1100 m). All the varieties responded positively to disease control (Table 6) since the principal disease was web blight, to which BAT 1297, BAT 1235, and BAT 1230 are partially resistant. The three BAT lines did not show any mean density response, but the more susceptible lines Uribe, ICA Line 24 and Calima all yielded more at lower density,

Table 5. Regional variety trial. Eastern Antioquia 1982A. Monoculture on stakes.

Variety	Color	Habit	Yield (kg/ha) C[a]	Yield (kg/ha) M[a]	Maturity (days)	Disease rating ANT[a]	Disease rating ASC[a]	Disease rating ALS[a]
Guatemala 457	Red	IVb	1357	4547	145	1.6	2.6	1.2
Guatemala 1243	Red	IVb	1915	3837	145	2.4	2.2	1.4
ICA La Selva 1	Cream/red	IVb	1719	2748	144	1.8	2.4	2.4
ICA La Selva 13	Red/cream	IVa	756	2549	146	1.2	2.6	1.2
V 5793-38	Yellow/red	IVa	740	2120	130	1.2	2.2	1.8
V 5761-32-35	Cream/red	IVa	509	1906	132	1.0	2.8	1.2
V 6785-325	Cream/red	IVa	162	1624	112	2.0	2.4	2.0
ICA Llanogrande (check)	Cream/purple	IVa	*[b]	2265	124	1.4	3.0	1.2
ICA Viboral (check)	Cream/red	IVb	724	2179	142	3.8	2.8	1.6
Mean			591	2088				
LSD (5%)			779	1351				

a. C = El Carmen; M = Marinilla; ANT = anthracnose; ASC = ascochyta leaf spot; ALS = angular leaf spot.
b. * = Both plots of this variety were lost at this site due to its field position.

Disease rating is mean of foliar ratings at four sites plus pod rating at 1 site; 1 = immune; 5 = very severe infection.

Table 6. Reaction of varieties to disease control and density. Caicedonia, Valle 1982A. *Monoculture.* (Thesis M. Osorio).

Variety	Disease control		Seeds/m^2	
	Without	With[a]	20	30
Uribe (local check)	277	472	455	293
ICA Line 24	885	1183	1117	952
Diacol Calima	1122	1375	1343	1153
BAT 1230	1348	1573	1428	1493
BAT 1235	2095	2410	2220	2285
BAT 1297	2283	2798	2547	2535
LSD (5%)	214			

a. Benomyl (0.25 kg/ha) + Maneb-Zinc (0.8 kg/ha) at 21 and 31 days after planting.

with or without disease control, although these differences were not significant. A negative density response would be expected because of the higher disease incidence recorded at higher density and because chemical disease control did not completely eliminate disease.

Stimulation of On-Farm Research in National Programs

The year 1982 was primarily devoted to methodology development, to establishing collaborative on-farm research with ICA in three new regions of Colombia and to planning training and network activities to be commenced in 1983. A brief workshop was held in Nariño to discuss on-farm research methodology and previous research. A verification trial was explained and distributed to the participants in a course held to launch the new variety ICA Llanogrande. In 1982, however, the promotion of on-farm research on beans was carried out mainly through informal personal contacts.

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1982 I

Bean Trials in the Coffee Growing Zone

In 1982, work continued under the ICA, CIAT, and Federación de Cafeteros joint project with the aim of promoting beans as a diversification alternative in the coffee growing regions. A great effort is being made to find one or several high yielding, widely acceptable bean varieties adapted to these conditions.

This joint effort already gave the first positive result with the release as a new variety in Colombia of the climbing bean line E-1056 under the name of ICA-Llanogrande. In order to have, as soon as possible, sufficient seed available of this new variety, approximately 1 ton of seed resulting from multiplication was distributed to different national institutions to continue with its rapid multiplication providing at the same time, good supervision of the process. Promising bush bean materials have also been identified such as BAT 1297, 1295, and 1235 which on average yield between 1550-1660 kg/ha in the coffee growing zone. These materials have desirable agronomic characteristics with respect to adaptation, tolerance to diseases, and high yields, but their consumer acceptability is limited due to its small grain type. Seed multiplications of these bush bean materials were also carried out; approximately 300 kg of each material were harvested, all of which were used for new multiplications in order to have in 1983 sufficient seed available to carry out commercial production trials and continue their multiplication.

Simultaneously, on-farm regional trials were continued with improved bush and climbing bean materials. Table 1 presents part of the results obtained.

Also two observation nurseries were planted in Chinchiná (Caldas) and Lejanías (Meta) where new materials showing good agronomic characteristics were evaluated and which will definitely solve the limitations related to commercial grain types once they have been assessed in the coffee growing zone.

In conjunction with the aforementioned activities, a series of intensive courses have been carried out with personnel responsible for the trials to familiarize them with handling of the materials under local conditions. These courses were offered at CIAT's headquarters from February 1 to 5, Pereira (Risaralda), June 21 to 25, and Rionegro (Antioquia), August 23 to 27 (Table 2).

A program was initiated in the agricultural training units to give short courses on bean cultivation to high school students who are considered key elements in crop promotion and adoption of new varieties.

Starting this year in Valle del Cauca, the Corporación Autónoma Regional del Cauca (CVC), the Institution responsible for conservation and development of the natural resources of the region and energy and water supply programs, is participating in these trials as a means of finding solutions to the food deficits in the area.

Table 1. Bush and climbing bean yields in 24 and 9 sites, respectively, 1982A.

Material	Average yield (kg/ha)
Bush beans	
BAT 1297	1554
BAT 1235	1368
BAT 1274	1133
ICA Llanogrande 24	925
Calima	853
Climbing beans	
V 8038	1741
V 8036	1538
E 1056	1190
Ancash 66	1092
ICA Viboral	1089

Table 2. Courses given by ICA-CIAT and FEDECAFE.

Site	CIAT	Chinchiná	Pasto	Armenia	CIAT	Pereira	Rionegro
Year	80B	81A	81B	81B	82A	82A	82B
Participants	37	32	22	20	22	43	22

Up to now the success of this project is partly due to the acceptable recovery of information from the trials done (Table 3) which has served to evaluate and select materials usable as good alternatives for the coffee growing zone.

Table 3. Information recovery relative to trials delivered.

Material	1980B		1981A		1981B		1982A		Total		Information recovery (%)
	Del[a]	Rec[a]	Del	Rec	Del	Rec	Del	Rec	Del	Rec	
Bush	13	11	28	19	32	19	35	24	108	73	67.5
Climbing	4	2	8	2	12	6	14	9	38	19	50

a. Del = trials delivered; Rec = results received.

19822

Economics

New technologies developed by the CIAT bean program in collaboration with national programs will achieve their ultimate objective - adoption by farmers - only if the new technologies are profitable for farmers. The main focus of economics research in the bean program therefore becomes the identification of which new technologies are the most profitable.

To assess the profitability of new technologies, both production oriented and market oriented research are needed. Profitability depends on the output (yield) of a new technology; the costs of production; and the price received for output. While production research examines output/cost relationships, marketing research appraises the probable price for output and estimates total potential demand.

Marketing Research

It is well known that grain type is an important determinant of the consumer acceptability and price of beans. The Bean Program takes this into account by including grain size, color, brilliance, and other characteristics as traits which must be maintained in new bean varieties in order to assure their marketability. Although general information on the types of beans appropriate for different markets is available (eg small reds for Central America, large reds for Andean countries; blacks in Brazil and Venezuela), a detailed specification of the requirements for beans in the various regional markets has been lacking. Bean economics has initiated market research in order to assure that the breeding program is neither too exigious in its concern to maintain grain quality, thereby potentially discarding promising material in the mistaken belief that it does not meet market standards; nor too lax in screening, thereby producing high yielding varieties which can find no market.

The objectives of bean marketing research are threefold. First, to establish on a market by market basis the key quality characteristics that determine bean prices. Second, to assess the flexibility of consumer preferences and their willingness to consume new varieties of grain types which are not identical to current commercial grain types. Third, to develop simple low cost methodologies for dealing with the first two issues.

Consumer preferences differ substantially, not only between countries, but also among regions within countries. It is well known, for example, that the types of beans on the market differ between the northeast and south of Brazil, as they also do between Medellín and Cali in Colombia. Because so many different markets for beans exist in Latin America, it is clearly far beyond the resources available to Bean Economics at CIAT to undertake an exhaustive investigation of all the major markets in the region. As a result, methodologies must be developed that can be readily adapted and utilized by national research programs even when they may not have had strong experience in economics or marketing research. A thorough assessment of regional markets depends ultimately on the success of individual national programs developing the capacity to assess the market requirements to which their own bean improvement programs must adhere.

Since a methodology for market appraisal is clearly needed, in 1982, various methods were tested in Cali, Colombia. Although further refinements are still required, the results of this year's experience will be presented here. Market share analysis was the first step utilized. Bean dealers - supermarkets, stores, wholesalers - were contacted, and some were found that had written records of their purchases or sale of beans by variety (Table 1). These results were compared with inventory counts of beans currently on sales at the retail level. While there certainly is variability over time in the market share of different varieties, shelf counts appear to give results that correspond reasonably well to written records.

The second stage of analysis was to undertake a survey of consumers. Table 1 shows marked differences in sales by variety depending on the type of retail outlet. Since the relative importance of different outlets in total bean sales are unknown, a direct approach to consumers is needed to determine total market share of different bean varieties.

Consequently in 1982 Bean Economics conducted a food consumption survey with 187 households in Cali, Colombia. From this survey average annual per capita dry bean consumption is estimated at 8.7 kg. This is well above the FAO estimated annual bean consumption in Colombia of 2.1 kg/capita. Because these Cali data are highly consistent with a previous food consumption survey conducted in Cali in the early 1970's which found an average bean consumption of 9.0 kg, it appears likely that the FAO data is a serious underestimate of actual Colombian bean consumption, which is probably in a minimum range of 4-5 kg/capita/year.

From the survey data it is possible to estimate the total market share of different bean varieties (Table 2). Red beans clearly dominate the market, but there are five major types of reds that are commonly consumed. Black beans have a very small market share, but white beans are fairly important. Beans eaten as green seeds, harvested at physiological maturity, are also an important form of consumption. The survey data clearly show that consumers in Cali do not rigidly limit their consumption of beans to one specific grain type, but rather that they are willing to consume a variety of grain types.

Total per capita annual bean consumption is fairly constant across income groups (Table 3), but the composition of this consumption by grain type changes. Small red beans, the cheapest varieties, are consumed primarily by the poor, while the consumption of this grain type falls as incomes rise. In contrast, the consumption of the more expensive large red beans rises with income. From these data it is clear that socio-economic variables, in this case income, can be as important a determinant of consumption as are preferences.

Table 1. Bean market shares (%), Medellín, Colombia.

Bean Variety	Supermarkets Records	Supermarkets Shelf Counts	Shops Records	Shops Shelf Counts
Cargamanto	36.5	40.7	20.0	19.0
Calima	23.5	22.7	19.8	15.1
Small Reds	15.3	19.4	36.8	37.8

Table 2. Market shares by bean variety, Cali, Colombia

Variety	Total Market (%)	Type
Calima	25.9	Red mottled
Caraota	2.5	Small Black
Cargamanto	4.8	Large Cream, mottled red
Blanquillo	16.7	White
Mortiño	12.7	Large red mottled
Radical	5.7	Red
Rojo Americano	13.6	Small red
Verde	17.2	Immature Green

SOURCE: 1982 Survey Data.

Table 3. Bean consumption by income class, Cali, Colombia (kg/cap/year).

Income	Total consumption	Small reds	Large reds
High income	8.7	3.0	3.0
Quartile 3	8.6	3.2	2.3
Quartile 2	9.5	5.3	1.4
Low income	8.8	5.0	1.3

SOURCE: 1982 Survey Data.

The survey also found direct evidence of consumer flexibility in Cali. Thirty percent of housewives surveyed reported that there is not a single bean variety that they usually purchase. Of households that were interviewed twice, 41% reported buying a different bean variety in July than in October.

The third stage of market research was direct consumer evaluation of new bean varieties. In this consumers first made a visual examination of new variety and then were given a free sample of a new variety for their own consumption. A subsequent evaluation of the new variety was obtained after it had been consumed.

Results are presented of these evaluations for ICA-Llanogrande (formerly E 1056), a newly released variety in Colombia that has been developed by a joint ICA/CIAT project. In visual evaluations Llanogrande was highly acceptable in size and shape, but faced some consumer resistance in color (Table 4). In the evaluation after having been eaten, Llanogrande obtained excellent evaluations in all characteristics except for color, and even in color this variety was qualified as average to good by 81% of the sample (Table 5). These results indicate both the utility of direct consumer evaluations of advanced materials and also the likelihood that Llanogrande is an acceptable grain type for the Cali market.

Table 4. Visual evaluation of new Llanogrande variety.

Characteristics	Good (%)	Average (%)	Poor (%)
Color	44	12	44
Size	75	6	19
Shape	74	12	12

SOURCE: 1982 Survey Data

Table 5. Eating evaluation of new Llanogrande variety

Characteristic	Good (%)	Average (%)	Poor (%)
Color	50	31	19
Taste	94	0	6
Texture	94	0	6

Various quality characteristics of bean grain types are hypothesized as being related to consumer preferences and prices. Such traits include size, color, cooking time, water absorption and broth thickness. Laboratory tests of these traits were conducted for the five principal red grain types found in the Cali market. These tests, undertaken by the Nutritional Quality Laboratory at CIAT, provided data that have been used to examine the relationship between quality and price.

For the Cali market, some characteristics such as cooking time and broth thickness, were found to have no statistically significant relation to price (most consumers use pressure cookers). In contrast, seed size was found to be strongly related to price in a linear regression equation.

$$(1) \quad y = 10.21 + 0.79\,x \qquad R^2 = .96$$

where y = retail price in pesos/lb and x = weight in grams of 100 seeds. Thus, this equation indicates that, for the Cali market given an acceptable color, seed size is the principal determinant of price. From this model the consumer price of ICA - Llanogrande is estimated at 51 pesos/kg, at prices prevailing as of July 1982. These results show that a careful study of quality characteristics of existing commercial varieties and their relation to price can provide valuable information to breeding programs as to the value of grain type traits.

Production Research

Production research in Bean Economics is involved in three major activities: constraints identification and production systems characterization; technology evaluation; and adoption and impact studies. These will now each be discussed in turn.

Constraints identification and production systems characterization provide information to other program scientists which can be useful to setting their research objectives and priorities. Analysis of available secondary data in bean production systems is the first stage of such studies. Collaboration with the Agroclimatological Unit at CIAT can be an important component of this research. Available secondary data must, however, be frequently supplemented with collection of primary data by Bean Economics in conjunction with other scientists.

A major effort undertaken in this type of activity in 1982 was conducted in close collaboration with the Cropping Systems Program of CIAT as a new set of on-farm trials with new bean technologies was initiated in a joint ICA/CIAT project in the district of Nariño, Colombia. This region was selected for farm trials due to progress achieved in ICA/CIAT bean breeding at La Selva and in Nariño; the wide diversity of bean cropping systems available in the area; the strong ICA/DRI presence in research and extension in Nariño; and the decline in bean production and withdrawal of ICA bean agronomists from Huila, Colombia, where some on farm trials were previously conducted.

Characterization of the main production systems and identification of critical constraints passed through three stages. First, in collaboration with the Cropping Systems program and with the assistance of ICA, a preliminary informal reconnaissance of the area was conducted. Fields were visited and discussions were held with farmers in order to get a general picture of bean production in Nariño. Second, available secondary data on bean production in Nariño were compiled. Based on the information gathered in these first two stages, knowledge gaps were identified and some hypotheses formulated. This provided the background for the design and execution of a formal survey of bean farmers in the area.

Some results of this process are presented in Tables 6 and 7. In Nariño three principal agroclimatic zones and three bean production systems have been identified after interviews with a sample of 100 farmers. In southern Nariño climbing beans are grown in direct association with maize at an altitude of 2400-2900 m. Beans are primarily grown for market in this zone. The main rotations are either maize + beans alternated with potatoes or cereals (wheat or barley), or maize + beans in successive years. Broad beans are sometimes grown in association with maize + beans. Input use among the small bean farmers of southern Nariño is quite high, with 93% fumigating, primarily fungicides, and 62% of farmers applying chemical fertilizer.

In central Nariño bush beans are grown in monoculture at an altitude of 900 - 1500 meters. The main rotation is with peas. Input use is somewhat lower in this zone, but still 75% of farmers fumigate and 40% apply chemical fertilizer. Again beans are grown for market. A few farms in this zone are comparatively large (more than 20 hectares). In northern Nariño bush beans are row intercropped with maize, with a row of maize interspersed between every three or four rows of beans.

Table 6. Four bean cropping systems in Colombia

Location	Eastern Antioquia	Southern Nariño	Northern Nariño	Central Nariño
Altitude (m)	2000-2300	2400-2900	900-1500	1800-2200
System	Relay	Association	Row intercropping	Monoculture
Growth habit	Climbing	Climbing	Bush	Bush
Main rotations	Potatoes maize/beans	Potatoes; maize/beans cereals	Maize/beans	Peas
Main variety	Cargamanto	Mortiño	Limoneño Calima	Argentino Calima

Table 7. Input use in four bean cropping systems, Colombia

	Eastern Antioquia	Southern Nariño	Central Nariño	Northern Nariño
Farms Fumigating (%)	100	93	75	3
Average number of fumigations	6.8	4.3	2.2	-
Farms using chemical fertilizer (%)	94	62	40	20
Fertilizer dosages (kg/ha)				
Nitrogen	45	17	12	9
Phosphorus (P)	33	11.44	8.36	12.32
Potassium	36.52	11.62	7.47	7.47
Farms treating Seed (%)	32	24	0	3
Number of farms surveyed (1982)	53	45	35	20

Input use is much lower in this zone, with practically no farmers applying fungicides or insecticides, and only 20% utilizing chemical fertilizer. Drought is a serious constraint in this zone, and nearly half the farmers are sharecroppers. These data on input use along with information on planting density, spatial arrangement and planting dates, were utilized by the Cropping Systems section in the design of the ICA/CIAT on-farm trials in Nariño.

Survey work was also conducted this year in three municipios in eastern Antioquia, where 53 farmers were interviewed. Although farm trials have been established in eastern Antioquia for some years now, until this year they were concentrated in one municipio. Hence, in order to provide baseline information on farmers current technologies in the new municipios into which the on-farm trials were introduced this year, a survey was conducted. It is also worth noting that in the municipio where the on-farm trials had been conducted for several years, some important changes in the use of fungicides were detected as farmers have adopted Benlate, a fungicide recommended due to its performance in the on-farm trials.

As well as providing data characterizing farmer production practices in the zones on which the farm trials are established, economics research also contributes to the on-farm research process through its participation in the evaluation of the trial results. This is a two stage process. First, through enterprise budget analysis, the profitability of new bean technology is compared with that of farmers' current bean technology. Second, new bean technologies are evaluated for their performance in the context of the whole farm.

This later analysis is achieved primarily through the construction of programming models. A linear programming model of farms of different sizes has been developed for eastern Antioquia. This year considerable work was undertaken to assess the potential of the new ICA-Llanogrande bean variety in this farm system.

The model for eastern Antioquia is one of income maximization with a subsistence food requirement that can be met either through on-farm production or purchase. Risk is not considered in this model. Optimal farm plans for this model introduce the Llanogrande bean variety into the solution in order to meet subsistence requirements for farms of all sizes. At a price estimated at 85% of the high quality Cargamanto bean currently grown by these farmers, Llanogrande would enter the optimal solution as a variety produced for commercial purposes. Llanogrande is currently being tested in on-farm trials elsewhere in Colombia, and its profitability in these other areas will be evaluated in order to identify the zone in which it could have the greatest potential for adoption by farmers.

As new bean technologies begin to be transferred to farmers, the third main activity of production oriented economics research comes into play. Follow up studies of new technologies as they are diffusing among farmers can be useful in identifying possible obstacles to the adoption of the new technology by some or all farmers. These results can be useful in making modifications in the technology in order to promote its adoption. Where diffusion proceeds easily without encountering difficulties, follow up surveys are useful in documenting the impact of new technologies. This information can be useful in planning future research activities.

19823

19823

International Collaboration

Outreach Project: Central America and Caribbean

This project is financed by the Swiss Development Cooperation (SDC), to develop technology appropriate for the region in close collaboration with national programs, and training of their personnel for the improvement of bean production and productivity in the region. Logistics to carry out these tasks efficiently are provided through agreements of CIAT with the Interamerican Institute for Agricultural Cooperation (IICA), and the Instituto de Ciencia y Tecnología Agrícola de Guatemala (ICTA) for the one scientist located in Costa Rica and the two scientists in Guatemala, respectively.

Summary of Project Achievements in 1982

During 1982 farm level testing of new released varieties from CIAT germplasm was emphasized in Honduras, Costa Rica, and Nicaragua. In addition, new sources of resistance were studied and an integrated control for web blight was developed which made bean production economically feasible in areas which have been previously abandoned to this crop because of this disease. With regard to BGMV, two agronomically acceptable red seeded lines were for the first time included in preliminary yield trials in El Salvador. In summary, the project identified better sources of resistance and adaptation to be incorporated into new improved bean materials and CIAT's bean improvement program.

In order to help national programs in transferring the new varieties and technologies to the farmers, in-country courses were emphasized during this year in Honduras, Costa Rica, Nicaragua, Guatemala, and Cuba. The courses in Costa Rica and Nicaragua were in collaboration with FAO, and the former had a regional ingredient since participants from Guatemala, Nicaragua, Honduras, and El Salvador were present.

Likewise, relatively large amounts of foundation seed of the newly developed varieties was increased at CIAT and provided to the programs in the region to speed up their availability to farmers.

Research Activities

Pathology

The 82-EP trial of CIAT, consisting of more than 300 advanced breeding lines, was evaluated in Guatemala for BGMV (Bean Golden Mosaic Virus); and in Costa Rica under two different levels of disease pressure for web blight (*Thanatephorus cucumeris*). The 82-EP demonstrated even more variability than last year's particularly for BGMV and may offer new sources of resistance.

Evaluation of materials tolerant to web blight was continued through the distribution of a second international web blight nursery (VIM), consisting of the best lines of the 1981 nursery. The VIM consisted of 35 materials in three replications and was distributed to, and planted in, Costa Rica, El Salvador, Guatemala, Nicaragua, Panama, and Mexico. Some of these entries are being crossed at CIAT and are the basis of a project to introduce tolerance to this disease to local commercial varieties.

An economic and efficient integrated web blight control was assayed successfully in Panama and Costa Rica. It consisted of reduced tillage, the formation of a mulch by weed control, two to three weeks after bean emergence with the inexpensive herbicide Gramoxone (1.5 l/ha), two applications of the fungicide benomyl (500 g/ha), two and four weeks after emergence, and the use of a relatively tolerant variety such as ICA-Palmar in Panama and Porrillo Sintético in Costa Rica. At the present time, more trials are in the field testing other herbicides, or combinations of them, and determining other factors which reduce the disease pressure.

Bean breeding

Bean golden mosaic virus. Presently, the golden mosaic breeding project is in a selection phase between cycles of intercrossing, thus, while work is continuing, there are few new results to report at this time. Soon we will be selecting in new crosses based on last year's results. We hope that these crosses will recombine different resistance sources and result in higher levels of resistance.

The most significant development in the BGMV project this year was the identification of early maturing black seeded lines with good levels of resistance. The later maturity of the released resistant varieties had been an impediment to their acceptance in some growing areas. In the long term, recovery of earliness in resistant lines may prove to be as important as the development of the resistance itself.

Apion godmani. This year another international *Apion* nursery was distributed to collaborators in El Salvador, Honduras, Guatemala, and Mexico. However, most of these nurseries were lost due to factors such as excess rain and flooding, or suffered only light *Apion* attack. Last year experience suggested that significant *Apion* damage does not occur during extended dry periods, hence planting dates will be critical to avoid dry periods and assure better attack.

To date only the Honduran collaborator has reported results from one of the international nurseries. Those results from Honduras confirmed last year's results from Guatemala.

Although the international nursery produced few results this year, three breeding nurseries of crosses involving resistant parents for combinations of local adaptation and resistance to diseases were evaluated with national program scientists. Breeding nurseries were established in Chimaltenango and Jutiapa (Guatemala), and in Zamorano

(Honduras). In the Jutiapa nursery, simultaneous selection was practiced for resistance to Apion and BGMV. Next year's results should indicate if the selection procedure has been effective.

Bacterial blight. Activities to incorporate resistance to Xanthomonas are continued as described previously. Observations in El Salvador, Guatemala, and Nicaragua suggest that the resistance selected in CIAT continues to be effective to the Central American isolates of the pathogen.

Web blight. Our experience in the past year with web blight has strengthened the hopes in the possibility of managing breeding nurseries to increase levels of resistance. The international nursery has served to confirm sources of resistance. We do not yet know how much genetic variability there may be among sources, nor what levels of resistance can hope to recover by recombining different genes. Nevertheless, it has been observed that some progenies of the Costa Rican cultivar Mexico 80 which were selected for overall agronomic value under local conditions in Costa Rica have better web blight resistance than their parent Mexico 80. This suggests that web blight resistance has improved almost without conscious selection. This bodes well for the possibilities of improving resistance with directed selection. The Costa Rican national program is currently testing resistance of 149 advanced black seeded lines selected by breeders in two cycles under web blight pressure, and this will permit to estimate how effective the selection for web blight resistance can be.

Introduction of breeding lines. In an attempt to obtain more information on local adaptation of CIAT breeding lines in Central America, 230 red seeded lines and 84 black seeded lines, as well as CIAT's progenitors in these two groups, were introduced from CIAT for planting in single row plots in Costa Rica, Honduras, El Salvador, and Guatemala according to local color preferences. Such introduction nurseries allow evaluation of greater genetic variability than is possible through yield nurseries, and offer greater probability of discovering adapted materials. This activity has already allowed identification of promising locally adapted lines with resistance to Xanthomonas, local rust races, and stable colors under Central American conditions. We anticipate that this sort of activity will increase in the next few years. Feedback from these nurseries will be invaluable in aiding CIAT to serve national programs more effectively.

Technology Transfer

From CIAT to national programs

The project received continuous support from the CIAT staff in research, training and personal visits as well as improved materials. The project staff visited frequently the different countries as needed either in helping in the selection of new germplasm, establishment of on-farm trials or in participating in in-country courses or training regional personnel in specific problems. During the year, 34 sets of the International Bean Yield and Adaptation Nursery (IBYAN) were distributed in Central America and 19 in the Caribbean according to the color and size preference of each country.

Of the climbing bean nursery, VIRAF, a total of 19 sets were distributed and planted in Central America. In addition, specific nurseries were distributed for anthracnose, rust, common bacterial blight, Apion, as well as for tolerance to low phosphorus and for heat tolerance. Finally, a total of eight sets of the CIAT Bean Program's Preliminary Yield Trials (EP's) were distributed and planted in the region for screening to regionally important production constrains such as BGMV, web blight, ascochyta, rust, Apion, and heat tolerance.

The capability of the national programs to manage and select germplasm in early generations enabled the evaluation in the region of a large number of F_3, F_4, F_5, etc. progenies for selection for local adaptation as well as for resistance to regionally important pests and diseases, thus accelerating the process of producing superior varieties for the region.

Among national programs in the region

Nurseries. The project assisted the Costa Rican and Guatemalan programs in the distribution and planting of the national yield nursery--VINAR.

In these nurseries, the performance of new promising germplasm is compared with local commercial varieties. A total of 30 sets were planted in Costa Rica and 10 in Guatemala.

The most recently created regional nursery, the VICAR (Vivero Centroamericano de Rendimiento), where new varieties produced by national programs are tested throughout the region, was enthusiastically accepted by the national programs. By their own initiative it was extended to the Caribbean countries. The VICAR contains red and black materials in separate sets. The nursery is distributed within the structure and under the auspices of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, PCCMCA. The Coordinator of the VICAR is the Coordinator of the national program whose country is hosting the respective PCCMA meeting. The project staff provides the logistics to make the nursery available to each country; to ensure that the results are delivered to the nursery coordinator on time to be reported during the PCCMA meeting; and to make the harvested seed available to the Instituto de Nutrición de Centro América y Panamá (INCAP) for analysis of protein content, aminoacid composition, and cooking time of the materials included in the VICAR's.

In 1982, a total of 44 sets of the VICAR, 22 red and 22 black, were planted in Costa Rica, Nicaragua, El Salvador, Guatemala, Honduras, and Panama.

The results shown in Tables 1, 2, 3, and 4 indicate an instability of some new varieties in their performance from one semester to the

Table 1. Mean yield in kg/ha of 14 VICAR Rojo 1981B varieties in different sites in Central America.

		El Salvador			Honduras		Nicaragua	Costa Rica		
No.	Variety	Atiquizaya	San Andres	Nueva Guadalupe	Catacamas	Las Acacias	Carazo	Alajuela	Perez Zeledon	Mean
1	Rojo 70	676 a[a]	2376 a	430	737 bc	1848 ab	1091 abc	3094 a	100 efg	1417
2	MCS-97R	610 ab	727 cde	332	722 bc	1931 a	1225 a	1214 b	379 ab	973
3	Rojo de Seda	454 bcd	808 c	582	625 bc	1594 a	1254 a	1365 c	327 ab	918
4	Honduras 46	474 bc	1193 b	264	1125 a	1550 abc	834 cd	1083 c	89 fg	907
5	Acacias 6	271 def	924 bc	462	903 abc	1166 ab	1033 c	1033 c	180 cdef	856
6	BAT 37	339 cde	769 cd	486	528 cde	1673 abc	1091 abc	1186 c	229 bcde	831
7	Acacias 4	343 cde	938 bc	507	612 bc	1442 abc	1060 abc	1082 c	208 bcdef	812
8	Local check 2	495 bc	601 cdef	85	222 e	1681 abc	1021 abcd	1360 c	304 abc	812
9	Local check 11	562 ab	614 cdef	304	570 cd	1653 abc	924 bcd	1042 c	254 abcd	803
10	Revolución 79	342 cde	602 cdef	444	222 ab	1375 bc	1181 ab	1700 c	146 def	795
11	Zamorano	173 e	441 def	222	417 cde	1223 c	1059 abc	1369 c	549 a	747
12	Mexico 80	352 cde	635 cdef	435	472 cde	1542 abc	1033 abcd	1225 c	243 abcd	736
13	BAT 1155	282 def	398 ef	119	528 cde	1764 ab	796 d	1208 c	31 g	715
14	BAT 859	108 f	338 f	161	278 de	1181 c	866 cd	1084 c	71 fg	561
Mean		391	812	345	569	1569	1043	1359	222	849
C.V. (%)		25.29	21.74	58.56	29.46	16.46	13.22	13.79	33.20	

a. Means followed by the same letter are not significantly different at level P = 0.05 (Duncan).

Table 2. Mean yield in kg/ha of 14 VICAR Negro 1981B varieties in different sites in Central America.

		El Salvador			Guatemala				Costa Rica		
No.	Variety	Atiquizaya	San Andres	Nueva Guadalupe	Jutiapa	San Jerónimo	Chimaltenango	La Máquina	Alajuela	Pérez Zeledon	Mean
1	ICTA Quetzal	572 abc[a]	723 bcd	1505 a	1038 a	2380 b	392	1267 ab	1547 cdef	351	1290
2	D-145	490 bcd	579 bcd	516 c	1036 a	2934 a	153	1133 bcd	1679 bcd	834	1195
3	Porrillo Sintético	443 cd	567 cd	1208 ab	840 abc	2261 b	191	1242 ab	1715 bc	944	1182
4	Brunca	747 a	614 bcd	1291 gb	731 abc	1970 bc	273	1033 bcd	1868 ab	478	1179
5	ICTA Tamazulapa	641 ab	617 bcd	1242 ab	666 bc	2390 b	302	1117 bcd	1457 def	835	1161
6	Local check 1	573 abc	1395 a	1309 ab	357 d	1506 d	201	842 cde	1975 a	325	1137
7	Talamanca	520 bcd	754 ncd	1267 ab	962 ab	2042 bc	85	1067 bcd	1336 fg	808	1135
8	MMS 008	664 ab	841 bc	128 ab	987 ab	1778 cd	165	1517 a	1589 cde	314	1073
9	ICTA Jutiapan	411 cd	382 d	1431 ab	759 abc	2362 b	134	767 de	1357 efg	410	1067
10	ICA Pijao	386 cd	474 cd	1523 a	887 abc	1716 cd	222	800 cde	1631 cd	659	1060
11	MMS 007	751 a	665 bcd	1210 ab	606 cd	1476 d	102	1183 abc	1489 cdef	634	1054
12	BAT 76	377 d	489 cd	896 bc	921 abc	2342 b	398	750 de	1319 fg	526	1013
13	Turrialba 1	525 bcd	454 cd	925 bc	943 ab	2313 b	267	483 e	1123 gh	608	967
14	Check	401 cd	962 b	-	780 abc	1726 cd	583	783 de	1045 h	500	950
Mean		536	680	1196	822	2086	248	999	1509	587	1105
C.V. (%)		18.17	29.60	23.04	20.60	10.88	53.78	20.73	8.65	40.18	

a. Means followed by the same letter are not significantly different at level P = 0.05 (Duncan).

Table 3. Mean yield in kg/ha of 14 VICAR Rojo 1982A varieties in different sites in Central America.

		Costa Rica		El Salvador		Nicaragua			% over
No.	Variety	E.E.F.B.	San Isidro	San Andŕes	Ahuachapan	Carazo	Rivas	Mean	Local check 1
1	BAT 789	2400	1261	1247	574	1361	487	1222	79
2	Revolución 81	1777	1435	1101	1144	1203	595	1209	77
3	Honduras 46	1654	1010	1358	1333	1225	460	1173	72
4	Acacias 4	1640	1270	1165	947	1331	579	1155	69
5	Huetar	2263	1512	944	709	883	451	1127	65
6	Revolución 79	2318	1275	665	316	1329	543	1074	57
7	DOR 164	2088	1410	866	529	914	394	1035	51
8	Chorotega	2071	1464	665	599	1155	219	1029	50
9	Centa Izalco	1857	-	1003	474	1098	529	992	45
10	Rojo de Seda	1617	949	1166	848	699	329	934	36
11	Mexico 80	1808	1245	403	323	877	149	800	17
12	Local check 2	-	1006	-	703	890	302	725	6
13	Local check 1	-	340	-	900	980	512	683	-
14	Zamorano	1433	397	192	231	-	90	469	-

Table 4. Mean yield in kg/ha of 14 VICAR Black 1982A, in different sites in Central America.

No.	Variety	Guatemala: Jutiapa	Guatemala: San Jerónimo	Costa Rica: E.E.F.B.	Costa Rica: San Isidro	El Salvador: San Andrés	El Salvador: Ahuachapan	Mean	% over Local check 1
1	Centa Tazumal	2387	2718	1575	1459	1600	850	1765	81
2	Talamanca	2903	2010	1200	1625	1406	1182	1721	76
3	Negro Huasteco 81	2740	1446	1878	1574	1198	821	1610	65
4	Porrillo Sintético	2596	1668	1735	1585	1183	873	1607	65
5	ICTA Tamazulapa	2622	1585	1612	1320	1408	847	1566	60
6	Centa Cristales	2574	2098	1453	1141	1233	708	1535	57
7	ICTA Quetzal	2732	1496	1732	1368	952	479	1460	50
8	ICTA Jutiapan	2685	1650	1705	1081	821	536	1413	45
9	ICA Pijao	2789	1268	1799	1295	741	567	1410	45
10	Brunca	2379	1510	1631	1429	997	470	1402	44
11	BAT 76	2504	1489	1429	1134	694	540	1290	32
12	Turrialba 1	2543	1368	1459	682	1035	550	1273	30
13	Local check 2	2167	1643	-	985	585	595	1195	22
14	Local check 1	1276	1564	1539	359	621	483	973	-

other; however, they also demonstrate the superiority in productivity of the new released varieties in comparison to the local commercial varieties. It is interesting to note the high agronomic performance of the Salvadorian red seeded variety, Rojo de Seda, throughout the region.

Agronomy. In 1982, on-farm evaluation trials of new released varieties were planted in Honduras, Nicaragua, and Costa Rica. Twenty-four tests were planted in collaboration with the Consejo Nacional de Producción (CNP) in Costa Rica, 24 in Honduras with the Secretaría de Recursos Naturales, and 45 in Nicaragua in collaboration with the Ministerio de Desarrollo Agropecuario y Reforma Agraria (MIDINRA) and FAO. All of them are oriented to promote the newly released varieties to small and medium-size farmers as well as to develop a minimum agronomic package for them. To the present, the results have shown that the new varieties are highly superior to the local varieties and the farmers are enthusiastically accepting them.

Varietal Release

In 1982, the national programs continued releasing new varieties produced from collaboratively developed germplasm. A total of eight new varieties were released by collaborating countries as follows: (1) Costa Rica released three red lines to replace the local Mexico 80: FB 5682-CM(15)-30-4-CM(12) as Huetar; FB 5675-CM(25)-24-CM(5) as Chorotega; DR 5680-CM(20)-17-CM(8)-CM as Corobicí; (2) Honduras named a sister line of Chorotega as Copán, superior in color and size to Acacias 4; (3) Cuba released the Colombian line from ICA, Line 23/24, as Hatuey 1; BAT 202 as Hatuey 2; and DOR 15 as Tomeguín 1; (4) and Mexico named the line D-145, developed from CIAT germplasm in Guatemala by ICTA within the BGMV project, as Negro Huasteco 81.

Seed Production

A high priority was given to assisting in the production of basic, registered and certified seed. In Costa Rica, a scheme of production was developed by which the breeder's, and basic seed were produced by the Ministerio de Agricultura y Ganadería (MAG) and the University of Costa Rica, and the registered and certified seed by the CNP under the control of the Oficina Nacional de Semillas (OFS). A seed committee consisting of members of all these institutions and the coordinator of the regional project, selected the varieties to be promoted and assigned the responsibilities of each institution in the amount and schedule for seed production. The schemes, however, differ substantially from one country to another, most of them being inefficient and inadequate. Nevertheless all the national programs made great efforts to produce large amounts of seed of the newly released varieties.

Studies by the socioeconomic program of ICTA have shown a significant adoption by the farmers in the Southeast of the new varieties, mainly Suchitan (ICA Pijao) and ICTA Tamazulapa. All the seed produced by ICTA and some private enterprises was completely sold

(150 t). Furthermore, the studies indicated that the national yield average which had stagnated at 480 kg/ha in the past decades has risen to 800 kg/ha over the last two years. In Costa Rica, the CNP, the only bean seed producing and selling institution, sold all the seed in stock. They sold 235 t of registered seed in 1981, and expect to sell in 1982 about 275 t, 50% of it is of the new variety Talamanca. Basic seed production is underway of the newest varieties, i.e., Brunca, Corobicí, Huetar, and Chorotega. Cuba has become self-sufficient with regard to seed, and has been able to export seed of ICA Pijao to Nicaragua. They are increasing rapidly other varieties to have a broader genetic variability in the near future. Nicaragua sold 228 t of Revolución 79, 16 t of Revolución 18, 38 t of Revolución 82 (Honduras 46), 35 t of Porrillo Sintético, and 7 t of ICA Pijao. A total of 325 t were produced. In Honduras, the seed division of the Secretaría de Recursos Naturales produced 70 t of Acacias 4. El Salvador was slowly producing basic seed of Tazumal mainly because of economic problems. Mexico planted 100 ha with Negro Huasteco 81 for basic seed production.

Training

A strong network of bean researchers has been established in the region through CIAT-based postgraduate internships that have specialized bean scientists in given aspects of bean research. Furthermore, this specialization has been strengthened through postgraduate studies that lead to a master's degree, whereby the thesis research is carried out at CIAT. During the year, the number of bean researchers has not increased because of budgetary reductions suffered by all national programs in the region.

On the other hand, it has been possible to increase the number of technicians trained in bean production by helping in the organization and conduction of in-country courses in Cuba (February 22-March 5), Costa Rica (July 19-30), and Honduras (November 15-26). The course in Costa Rica was partially financed by FAO. Project personnel as well as CIAT-based personnel participated actively in these courses.

The two current candidates for M.Sc. degree studies finished their course studies at the Universidad Federal the Vicosa, in Vicosa, Brazil, and at the present time are at CIAT conducting their thesis research under the supervision of the Bean Program staff.

In terms of postgraduate interns, a total of 14 professionals were sent from the region to CIAT for training, and one from the Dominican Republic to Guatemala for special training in BGMV. These candidates came from Costa Rica, Cuba, the Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, and Mexico.

Other Activities

At the request of Honduras and Nicaragua, project personnel provided assistance in the development of projects to be presented to donors for financing. The project staff also helped in the organization and actively participated in the 1982 PCCMCA meeting, in San José, Costa Rica.

The coordinator participated with staff of SDC in Tegucigalpa, Honduras, in the discussion and negotiation of the expansion of this project known as Project T.311 Frijol América Central 6.

Future Plans

The project will continue to expand the introduction into the region of early generation tailor-made but especially of locally and collaboratively developed new bean materials to improve and correct those weaknesses of the currently released varieties, for example earliness, rust resistance to the specific races of the region, increase in seed size, color stability, particularly in the red seeded lines and drought tolerance. The ability of new varieties to climb, and therefore, to do well in monoculture as well as in relay cropping systems will be emphasized. Some of the new varieties such as Acacias 4, Revolución 79, and Brunca have shown ability to climb when planted with maize and yield well.

In order to increase the communication links between the various national efforts in the region, and to facilitate horizontal transfer of technology generated in the national programs, the project will increasingly emphasize the organization of field workshops and other events that allow for direct interpersonal contacts among bean workers in the region.

The project will give more attention to generate simple agronomic technology through farm level evaluation to solve local constraints economically and efficiently. Expansion of the capacity for seed production is a basic need to reach increased productivity with the new varieties.

The project has attained some goals faster than anticipated. Varieties have been released and adopted by the medium and small-size farmers. Therefore, it is believed that an economist is needed to work directly in the field with farmers and agronomists in the farm trials to conduct an economic input analysis and determine whether or not the newly generated technology is profitable and will have an impact on bean production in the region.

Outreach Project Brazil

Total bean production of Brazil is superior to that of all other Latin American countries, including Mexico. In 1981 alone 5,054,000 ha were planted in beans which produced about 2,362,700 tons of dry beans (data: SNPA). The average yield was less than 500 kg/ha. There are two main factors responsible for the low yields:

1) In the recent years beans were displaced from the relatively more fertile to infertile soils, by the more lucrative crops such as soybeans and sorghum.

2) The limited availability of improved varieties. At the present time less than 10 cultivars are grown on a large scale in Brazil of about 30 cultivars recommended by the state institutions. Most of these varieties are selections from introduced materials and only few result from breeding work. There is a tendency to eliminate the more risky varieties, e.g., Roxao, Rosinha, Jalo, Enxofre, Manteigao, etc., although these command a high price in certain locations. This would further narrow the genetic variability of varieties used which is already limited. Current popular varieties are: IPA 74-19, Mulatinho Vagem Roxa, Rio Tibagi, Carioca, Moruna, Manteigao 977, Rim de Porco, Tayhu, Rosinha, Ricopardo 896. The high priced medium to large seeded varieties produced on small farms normally have limited markets (mostly in the Minas Gerais State).

Carioca is the only variety that is increasing its dominance over all varieties in all states, owing to its unique varietal characteristics; broad adaptation, stability in yield across locations and years and a good cooking quality, although Carioca is susceptible to almost all diseases except BCMV.

To increase bean productivity through varietal improvement, the national varietal evaluation and recommendation network for beans (and other crops) was established. CNPAF is responsible for beans and rice. The evaluation scheme for beans is comprised of three stages: 1) the preliminary yield trials; 2) the state trials; and 3) the regional trials, which will complete one cycle of four years of testing (Figure 1). This new network does not change the existing bean germplasm introduction and evaluation system in each state, but creates more uniformity and increases the number of materials in each stage of testing.

Since this network is the only official vehicle to introduce foreign lines into Brazil, the following objectives, strategies, and working schedule for CIAT advanced breeding lines to be included in this scheme are proposed.

Objectives

1) To evaluate the CIAT advanced breeding lines under Brazilian conditions.

2) To distribute the outstanding lines to different bean growing regions through participating in the national bean evaluation and recommendation network.

3) To supply the Brazilian bean research entities with specific materials for their genetic improvement projects.

Strategies

1) To evaluate as many as possible CIAT advanced breeding lines in two or three consecutive semesters at CNPAF and other sites with different agroclimatic conditions.

2) To participate actively in the introduction nursery of beans in CNPAF. This is the first stage of evaluation of CIAT lines. CIAT breeder must visit three nurseries (February-June).

3) To multiply the selected lines as fast as possible to enable participation in the national bean evaluation and recommendation network in the same year (October-January).

4) To understand more the regional specific problems and requirements of beans by visiting the regions and evaluate the lines.

Time Schedules

The National Bean Evaluation and Recommendation Network (NBERN) will complete its cycle in a minimum of four years and maximally in six years. Each year the nursery is upgraded by discarding the poor performers and substituting these for new lines (Figure 1). In order to be able to supply the NBERN yearly with well-adapted CIAT lines, it is necessary to receive from CIAT sufficient advanced breeding lines yearly, which fulfill the Brazilian seed color and size requirements. New CIAT lines will follow the introduction scheme shown in Figure 2. CIAT breeder and pathologist are expected to evaluate the lines each May at CNPAF and mid December in serveral locations, where the NBERN is conducted.

Research Activities

The main production constraint at the CNPAF Goiania site and most other locations are soil problems. Research activities concentrated in this area are:

- Split N applications as a measurement against leeching.
- NPK location specific experiments.
- Low tolerance screening, which runs simultaneously with the seed multiplication stage.

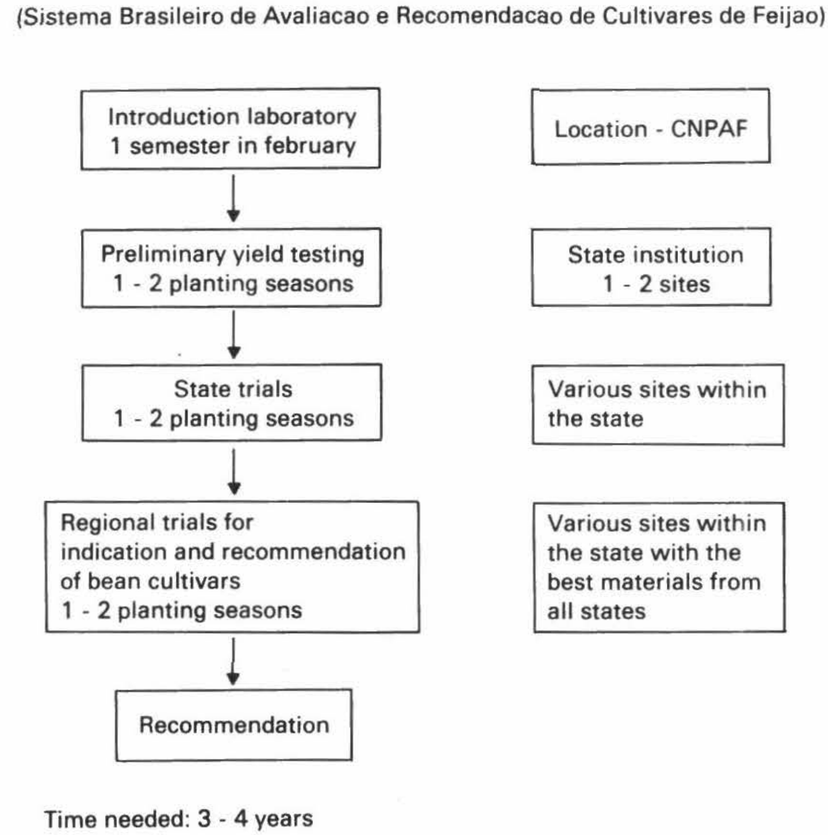

Figure 1. National bean evaluation and recommendation network (NBERN).

Projections

New CIAT lines as identified through the NBERN will show up in Brazil as recommended cultivars at the earliest in 1987, whereas previously introduced CIAT lines into Brazil through the IBYAN will become varieties in the coming years.

All special projects where CIAT is involved should be discussed at CNPAF first and all CIAT visits to Brazil must be channelled through CNPAF. These measurements will avoid misunderstandings that could influence the CIAT germplasm flow to Brazil.

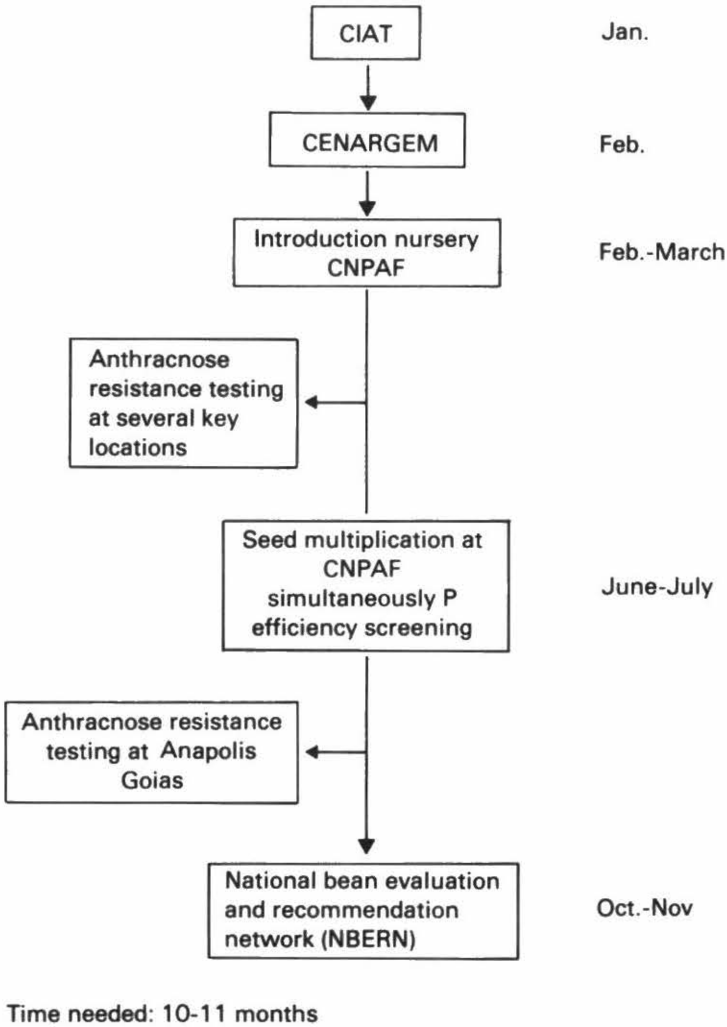

Figure 2. Working schedule to introduce germplasm each year into Brazil.

19824

International Collaboration - Perú

During 1982 this Swiss funded project completed three years of activities. The following have been developed:

Germplasm Introductions from CIAT

Through the International Bean Yield and Adaptation Nursery (IBYAN), CIAT-finished materials were tested in four black trials, seven white trials, seven red large-seeded and climbing bean trials.

Also, 310 segregating materials in early generations from crosses specifically designed to obtain grain types locally consumed in the coast were tested. Another 573 segregating climbing F_3 bean lines were planted in the Sierra to obtain large grain types traditionally consumed in this region. The EP 81 was also repeated in another site with seeds from the original trial that was harvested in Lambayeque.

National Trials

These trials were carried out in several sites and included lines introduced from CIAT and materials from the national program. These trials have been divided into regions according to the type of beans required in each and the prevailing cropping system.

The first basic seed increases have been carried out, and seed is already available for four lines for the northern coast; three "bayos" and two "canarios" for the central coast; the climbing bean "Gloriabama" (introduced from CIAT as G 2829) for the growing conditions in the Sierra in association with maize; and two bush bean varieties for the southern Sierra.

Training

A researcher from the national bean program received 5½ months training in Colombia and the Program's breeder worked on his MS thesis at CIAT, Colombia, after completing his studies in La Molina.

CIAT gave logistic support for a regional course on grain production in Trujillo with 25 participants.

Workshops

The annual meeting of the Bean Regional Program took place in April in the northern coast with the participation of 22 regional scientists. All the Bean Program personnel met in Lambayeque in August to design their working plans at the national level. In October, a workshop on

Pest Management in Beans was organized with the participation of 12 scientists in this area.

Future Plans

Populations from adequate crosses to obtain the desired grain type will be developed in three experimental stations of the country. Crosses will also be made in CIAT for both bush and climbing beans which will be sent to Peru in early generations.

Selections will be locally made in several sites. In the three principal stations, separate projects will be carried out for each problem.

The agronomic trials on cultural practices such as planting density and system, land preparation, irrigation, chemical and mechanical control of pests, etc. will be expanded.

Production of basic seed will be the responsibility of seed agronomists from the multidisciplinary team of the National Bean Program and commercial seed production by the private sector will be encouraged through adequate incentives, taking advantage of alternate cropping seasons in the different regions of the country.

19825

Bean Research at IVT, Wageningen, Netherlands

Incorporation of Resistance Genes to Bean Common Mosaic Virus (BCMV) into CIAT Breeding Lines

Program A with IVT 7233 x IVT 7214

Eleven F_3 lines of B_1 CIAT progenitor x F_3 (IVT 7233 x IVT 7214) with complete resistance to BCMV and bean yellow mosaic virus (BYMV) were sent to CIAT in January for making the second backcross (B_2).

Backcrosses with CIAT breeding lines were made in CIAT and seed multiplied to F_2. Nine F_2 populations were sent to IVT in October for testing and to make testcrosses with resistant F_2 plants. This is to detect those plants that have the double resistance to BCMV, viz. the genes bc-u + bc-3 and $bc\text{-}2^2$ + I. As the testcrosses cannot be made in the Netherlands during December and January the program will be continued in February 1983.

A number of F_3, F_4, and F_5 lines of B_0 or B_1 of the crosses was tested for resistance to Colletotrichum races iota, alpha Brazil, epsilon Kenya, and Colombia 236. Two out of 14 lines were resistant to all four races. This resistance was derived from BAT 44 and BAT 1235 as CIAT-parents. The test has to be repeated, however, with all races plus lambda, as the infection with C236 and iota was too low and lambda could not be used.

Program B with IVT 7620

F_4 or F_5 lines of B_0 CIAT progenitor x IVT 7620 were tested with Colletotrichum races lambda, iota, alpha Brazil, and Colombia 236 to assess their resistance to anthracnose. Eight lines out of 24 with the best resistance to anthracnose and all with complete resistance to BCMV and BYMV were brought to CIAT in January for making the first backcross to CIAT breeding lines. The F_2 B_1 from crosses with 15 CIAT breeding lines arrived at IVT in October and will be tested and test-crossed in 1983 to select again lines with complete resistance to BCMV and BYMV, and the best resistance to anthracnose.

The continuation of programs A and B turned out in such a way that no F_2 populations of the new CIAT crosses became available in 1982 during the summer which is the best time for bean growth in Holland.

A new time table has been developed now to assure that F_2 populations from at least one of both programs will become available for testing and seed production during the summer in IVT.

Testing of CIAT Breeding Materials for Detection of Gene I

Ten proposed parents for the second backcrosses of program A (with IVT 7214 x IVT 7233) were tested with BCMV-NL3 to determine presence of gene I. Two lines did not have this gene and CIAT was advised not to use them in the backcross program.

Ten proposed parents for the first backcross of program B (with IVT 7620) were tested in the same manner. Three parents had no gene I and two were heterogeneous for that gene. They were discarded for the backcrosses. Twenty-five current parents for development of I-gene azufrado and bayo grain types for Peru were tested. Two parents had not gene I and two were heterogenous for I.

Eleven best red mottled entries from VEF 1981 of excellent Andean grain color type were tested for presence of I gene. Four entries did not have gene I and two were heterogeneous. It was advised to exclude them from further crosses.

Seventeen additional varieties and breeding lines were tested for detection of I gene and recessive genes. Seven did not have gene I and one was heterogenous. They had neither the recessive genes bc-2^2 or bc-3. The other resistance genes, some of which might have been present, are not important.

Four selections, meant for parents in a color/I gene linkage study, were checked for presence of gene I. Two had genotype II and two ii, as expected.

Twenty-four individual selections from families were tested with strains NL3 and NL8 separately. Five selections had genotype ii instead of II. It is advised to discard them from further selection.

Sixteen selections of Andean grain color type were tested in the same manner. Thirteen were not of the genotype II.

Identification of Resistance Genes for BCMV in Progenitors

One hundred and eight CIAT progenitors were tested with strains of BCMV for identification of the resistance genes. Thirty-three of them had gene I. It still has to be investigated for most of them whether they also have recessive bc-genes, and if so which ones. Gene I was not present in 75 accessions and breeding lines and 64 of them neither had recessive bc-genes. Three had bc-1, two bc-1^2, and two bc-1^2 + bc-2. The bc-genes have to be identified in another four recessive genotypes.

The accessions Don Timoteo and Great Northern 164.557 were both resistant to all strains of BCMV and therefore of great interest. The Great Northern accession has gene I, Don Timoteo does not. Both accessions were testcrossed to IVT 7214 for identification of bc-genes. It became evident after testing the F_1 of the testcrosses that Don Timoteo has gene bc-3, like IVT 7214, or it has a new dominant gene (not gene I). Great Northern 164.557 has besides gene I not bc-3. It must have another recessive gene preventing systemic necrosis in the homozygous genotype. This could be bc-2^2 as in IVT 7233. New testcrosses are being made with Don Timoteo and Great Northern 164.557 for further identification of their resistance genes.

Testing of CIAT Progenitors with Races of Colletotrichum lindemuthianum

Nine progenitors, received from Dr. Davis in 1981, were again tested in 1982, as the reaction of some races of the fungus was too weak in the preceding year. The results did not differ much from those obtained in 1981. Again, Antioquia 123 had a very good resistance, being only susceptible to race alpha Brazil, thus carrying that same resistance as differential Mexique 222.

Selection of II-Genotypes with Red-Mottled Seed Color

During tests with breeding lines from Dr. Temple to detect II-genotypes in red-mottled seed types, a line was found to be heterogenous for presence of gene I in the plants, and with the wanted seed color. Plants with and without gene I were selected and seeds from these plants were harvested. The progenies of four plants (two with and two without gene I) were sown and each plant of the progenies was tested for presence of gene I through the necrosis leaf test. The plants of the two lines selected for absence of gene I were all negative in the test and the plants of the two lines carrying I all positive, indicating that the lines were now uniform and homozygous.

Seeds of all plants of both lines with gene I were separately harvested and checked for seed color. All progenies are so-called purple-mottled which is a bit darker than the more bright red-mottled color of beans without gene I. As all 32 plant progenies from two lines have the same seed color, there were no recombinations between gene I and the gene for color shade. The selections will be handed over to Dr. Temple after a confirmation test for presence of gene I.

19826

Scientific Training

During 1982, the activities of the Bean Scientific Training Program were oriented, within the framework of the general objectives of CIAT's training, towards the implementation of the following goals:

1. To train experts and scientists of national programs, especially on activities related to evaluation of promissory germplasm.

2. To help increase the capability of national bean research programs to conduct cooperative and independent crop improvement research.

3. To build up and strengthen the national and international research networks dealing with the exchange, testing, validation and transfer of improved germplasm and accessory technology.

4. To render support to the coupling of research and extension by means of activities oriented towards an effective and rapid transfer of new varieties and related technology to farmers through national institutions.

5. To collaborate in the preparation of training materials.

It should be pointed out that the achievements and advances of Bean Program researchers and scientists in the collaborative research network, concerning the generation of improved lines for different countries, made it possible to conduct training activities parallel and complementary to the activities of researchers in these countries. This means that the training efforts during 1982 took place largely outside CIAT along with the release of new varieties. It included also the support given to in-country courses in Cuba, Brazil, Costa Rica, Honduras, and three in Colombia, one of which related to the release of variety "ICA-Llanogrande". These activities are part of the evolution of training efforts, from an emphasis on short, intensive, multidisciplinary courses during 1977-1979, to medium term specialized training activities in CIAT during 1980-1981, and to courses outside headquarters in 1981-1982, as well as training related to M.S. and Ph.D. theses.

One feature stressed during the training courses conducted with the Federación Nacional de Cafeteros of Colombia was that at the end of the course each participant left with an experiment kit containing advanced lines for testing in his location of work. During the course, participants received training in seeding and in the implementation of those trials using the "learning by doing"methodology. Far from being academic exercises, these courses, by means of these trials, contribute to testing of new germplasm generated by the Bean Program. The recovery information obtained from by these trials is surprising: out of 26 trials submitted to experts of the Federación de Cafeteros and the Corporación Autónoma Regional del Cauca, CVC, 22 produced harvest information during the first six months. At present, there are 80 trials established by experts of these two institutions, all of them trained by CIAT or in cooperative courses. The same was done in the course in Costa Rica, and it will be a pattern for future courses.

Training has enabled the Bean Program to cooperate with a large number of countries, 33 in total, of which 24 belong to the developing world. A total of 392 of their professionals were trained in beans at CIAT between 1972 and 1982. Figure 1 shows the priority given to the Latin American countries, where beans constitute a highly important nourishment produced by small farmers. It also shows the participation of African scientists in training activities, thus expanding research work on beans to Africa. Figure 1 shows the countries of origin of all the professionals trained in beans by CIAT during the period 1972 to 1982. Table 1 gives similar information for the year 1982.

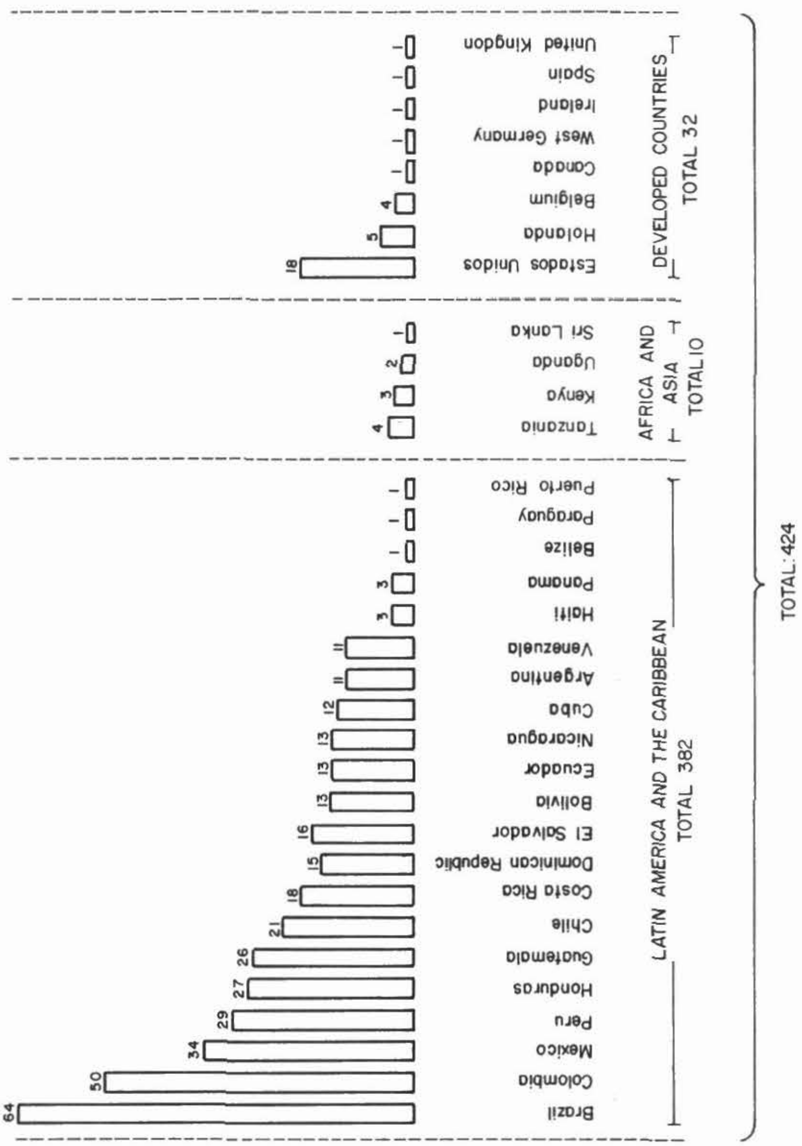

Figure 1. Number of professionals trained at the Bean Program until 1982, by country of origin.

Table 1. Number of professionals trained at the Bean Program during 1982, by country of origin.

Country	Participants
Argentina	1
Belgium	2
Bolivia	2
Brazil	3
Colombia	5
Costa Rica	1
Cuba	1
Chile	1
Dominican Republic	1
El Salvador	1
United States	5
Guatemala	3
Netherlands	1
Honduras	4
Mexico	3
Nicaragua	5
Paraguay	1
Peru	3
Total	43

Training Activities at CIAT Headquarters during 1982

Training program for bean research

A program for developing of scientific capability for bean research was implemented in 1982. It started with the 9th edition of the Intensive Multidisciplinary Phase for Research on Bean Production, with participation of 22 "visiting researchers" from Colombia (4), Brazil (3), Mexico (3), Peru (2), Guatemala (2), Honduras (2), Costa Rica (1), Cuba (1), Nicaragua (1), Dominican Republic (1), El Salvador (1), Bolivia (1). This intensive phase was intended to revise and update in an integrating manner and a multidisciplinary focus research methodology on beans, existing and new technologies being generated as a solution to the crop's priority problems. Thirteen out of the 22 "visiting researchers" continued into a 15-week specialization period within a specific discipline. In this phase, preselected program scientists supervise individually each one of the participants in important aspects of planning, executing and analyzing research projects.

Table 2 shows the different training categories and the corresponding disciplines of specialization for the 43 professionals trained at CIAT during 1982. Major emphasis was on genetic crop improvement and agronomy. Due to frequent demand from the national training programs in agronomy, a group of seven visiting researchers was appointed to continue specialization during four months. Table 8 at the end of this section gives a complete account of the professionals trained in the Bean Program in 1982.

Degree related academic training

One of the main aims of the Bean Program is to contribute to the development of scientific leadership and improvement of the human resources assigned to research in the national institutions. For this reason, special attention was given to identifying candidates for Ph.D. and M.S. degrees related to research training. This training strategy is based on the selection of candidates with long permanency in research in their institutions and who, after obtaining higher academic degrees, will guarantee their continuity with the programs. Two researchers concluded their Ph.D. thesis and three continued research for the same degree. Furthermore, six professionals concluded research for a M.S., degree, while four others carry on this year their research for the same degree. Table 3 shows names, nationalities, institutions, and major field of study of each of them.

National programs receiving training contributions

Table 4 shows national institutions receiving training collaboration from CIAT during 1982. All of them are national institutions with research programs on beans. Special attention was given this year to strengthening those programs.

Post-doctoral fellows

Three post-doctoral scientists spent training time in the Bean Program in 1982. Two of them worked on breeding projects and the other one in an entomology project. Table 5 shows their names, country of origin and field of work.

Assistance to in-country courses

In-country courses mostly for extension and university staff have the purpose of speeding up the spread of new varieties and yield increasing cultural practices. Also, these two to four week courses contribute to the development of collaborative networks within the countries and to linking of research and extension. Assistance was given in 1982 to courses in Cuba, Brazil, Costa Rica, and Honduras. Also, three courses were carried out in Colombia. Table 6 shows the institutions with which CIAT collaborated, their headquarters, and number of participants.

Table 2. Professionals trained in beans at CIAT in 1982 by discipline of specialization, and category of training.

	Category of training						
	Visiting associate researchers		Visiting researchers				
Commodity/discipline of specialization	Thesis Ph.D. No. months	Non-thesis No. months	Thesis M.S. No. months	Specialization No. months	Specialization in multidisciplinary intensive course No. months	Multidisciplinary intensive course participants No. months	Subtotal No. months
Beans							
Agronomy					6 (33)		6 (33)
Genetic Resources	1 (7)						1 (7)
Plant Breeding	4 (37)		3 (25)	2 (7)	2 (11)		11 (80)
Plant Pathology			3 (27)		1 (4)		4 (31)
Entomology			1 (9)		1 (5)		2 (14)
Multidisciplinary			1 (3)				1 (3)
Soil Microbiology			1 (6)				1 (6)
Seed Production				2 (7)	2 (11)		4 (18)
Biometrics					1 (4)		1 (4)
Plant Physiology				1 (3)			1 (3)
Production Research[a]						9 (13)	9 (13)
Quality Nutrition		1 (6)					1 (6)
Beans total	5 (44)	1 (6)	9 (70)	5 (17)	13 (68)	9 (13)	42 (218

a. Multidisciplinary, research intensive short courses.

Table 3. Degree related training.

Name	Country	Institution	Discipline
Visiting associate researchers, Ph.D. Thesis			
1. Thierry Vanderborght	Belgium	U. of Gembloux - FAO	Genetic Resources
2. Julia Kornegay	United States	Cornell University	Breeding
3. Paul Gnifke	United States	Cornell University	Breeding
4. Elizabeth Lewinson	Belgium	U. of Gembloux	Breeding
5. Jeffrey McElroy	United States	Cornell University	Breeding
Visiting researchers, M.S. Thesis (completed)			
6. César Apolitano	Peru	INIPA	Breeding
7. Julio César Hernández	Nicaragua	Mida-INRA	Entomology
8. Alfredo Pérez	Bolivia	U. Boliviana Gabriel René Moreno	Breeding
9. Edgar Santacruz	Colombia	FEDECAFE	Breeding
10. Héctor Fernández	Honduras	Ministerio Recursos Naturales	Breeding
11. Jodi Parker	United States	University of California	Interdisciplinary
Visiting researchers M.S. Thesis (in progress)			
12. Samuel Ajquejay	Guatemala	ICTA	Breeding
13. Bernardo Mora	Costa Rica	Ministry of Agriculture	Fitopatology
14. Jaap Haanschoten	Netherlands	University of Florida	Soil Microbiology
15. Maria E. Irastorza	Argentina	Universidad de Córdoba	Seed Technology

Table 4. National institutions with which the Bean Program has collaborated through training in 1982.

Country	Institution	No. participants
Training		
Belgium	University of Gembloux	1
	FAO	1
Bolivia	U. Boliviana Gabriel René Moreno	1
	Plan Desarural Velas - PLADERVE	1
Brazil	IAPAR	1
	PESAGRO - Río	1
	Instituto Agronómico - SP	1
Colombia	ICA	2
	Federación Nacional de Cafeteros	2
	CVC	1
Costa Rica	Ministerio de Agricultura y Ganadería	1
Cuba	Ministerio de la Agricultura	1
Chile	INIA	1
Dominican Republic	Secretaría de Estado de Agricultura	1
El Salvador	CENTA	1
Guatemala	ICTA	3
Honduras	Ministerio de Recursos Naturales	4
Mexico	INIA	3
Nicaragua	MIDA INRA	4
	U. Nacional Autónoma de Nicaragua	1
Paraguay	MINAGRIC-Ganadería	1
Peru	INIPA	3
Training (in-country courses)		
Brazil	EMBRAPA - CNPAF	28
Cuba	Ministerio de Agricultura	20
Colombia	ICA, FEDECAFE, CVC	87
Honduras	Ministerio de Recursos Naturales	25

Some of the features of in-country courses are:

- A multidisciplinary focus, with emphasis on local priority problems, and on the potential of new varieties and of cultural and protection practices for overcoming those problems and increasing bean yields.

- Special emphasis is given to the development of skills to carry out experimental tests on adaptation and validation of the new germplasm. At the course in Costa Rica it was possible to submit an experimental test--the Vivero Nacional de Adaptación y Rendimiento, VINAR--to each one of the participants.

- Approximately 80% of the training and organization of the courses is done by researchers trained at CIAT.

- The courses made heavy use of audiotutorial units for teaching.

Concerning Colombia, the main purpose of the courses held in collaboration with ICA and the Federación Nacional de Cafeteros is to support germplasm testing of promissory bean lines for the coffee zone of the country, where beans are a vital component of the daily food. This collaboration began in the second half of 1980. Table 7 summarizes all training courses given. Similar work was conducted during the first six months of the year with the Corporación Autónoma Regional del Cauca (CVC).

Table 5. Postdoctoral fellows in the Bean Program in 1982.

Name	Procedence/country	Discipline	Project
Michael Dessert	Michigan S.U./USA	Breeding/Pathology	Resistance to rust and bacteriosis
James Nienhuis	U. of Wisconsin/USA	Breeding	Plant architecture
Guy Hallman	Texas AM.U./USA	Entomology	Resistance to leafhoppers, bruchids, and Apion

Table 6. In-country courses, Bean Program 1982.

Country	Institution	Dates	Participants
Colombia	FEDECAFE, CVC	February 1-5	22
Colombia	ICA	August 23-27	22
Colombia	FEDECAFE	June 21-26	43
Cuba	MINAG	February 21- March 5	20
Brazil	EMBRAPA/CNPAF	March 14 - April 3	28
Costa Rica	MINAG, U. Costa Rica	July 19-30	27
Honduras	SRN	November 15-26	25
		Total	187

Table 7. Training courses on beans conducted in cooperation with the national coffee growers federation, ICA, and CVC, 1980-1982.

Date	Location	Participants
1980 - B	CIAT	37
1981 - A	Chinchiná	32
1981 - B	Pasto	22
1981 - B	Armenia	20
1982 - A	CIAT	22[a]
1982 - A	Pereira	43
1982 - B	Rionegro[b]	22
	Total	198

a. Seven participants from CVC.

b. Organized with ICA-ORI and related to release of the new variety ICA-Llanogrande.

At present 80 trials are in process at different locations with the Coffee Growers Federation. Seven of them are planted in the Federations "agricultural centers" where the Federation plans to train, in 1983, 400 young farmers and technicians to use trial results for seed increase, validation, and demonstrations with outstanding materials.

Development of training materials

The production of audiotutorial units continued on various aspects of field beans research and technology, with the strong participation of training associates and Bean Program staff. Twenty one units have been completed to date. They are used extensively in training courses at headquarters and in the countries as well as by interested individuals. Several units produced since 1977 are now in process of revision and up-dating.

Conferences

A Field Workshop of Bean Breeders was held at CIAT from November 23 to 30, 1982, with the purpose of congregating breeders from national programs of Latin American countries who have selected varieties using CIAT's generated germplasm and crosses or germplasm from collaborative projects. Thirteen breeders participated in an exercise combining a few conference room discussions and long hours in the field selecting new lines potentially useful to them. They took back seed or placed their orders for delivery upon harvest. During the meeting priorities for bean improvement were established and adjustments were made regarding the operation of research work especially in regards to the national program needs.

Table 8. Visiting researchers in the Bean Program, by disciplines of training, 1982.

Name	Country	Institution	Short course participants	Discipline	Supervisor	Months	Stage
Visiting associate researchers, Ph.D. thesis							
Vanderborght, Thierry	Belgium	FAO, Rome		Germplasm-genetic resources	Schoonhoven, A.v.	7	C[a]
Kornegay, Julia	USA	North Carolina State Univ.		Plant breeding	Temple, S.	7	C
Gnifke, Paul	USA	Cornell Univ.		Plant breeding	Davis, J.	12	P[b]
Lewinson, Elizabeth	Belgium	Gembloux Univ.		Plant Breeding	Davis, J.	12	P
McElroy, Jeffrey	USA	Cornell Univ.		Plant breeding	Temple, S.	6	P
Visiting associate researcher							
Dessert, Krista	USA	Independent		Nutritional quality	Gómez, G.	6	P
Visiting researchers, M.S. thesis							
Ajquejay, Samuel	Guatemala	ICTA		Plant breeding	Davis, J.	6	P
Fernández, Héctor	Honduras	Ministerio de Rec. Nautrales		Plant pathology	Pastor-C., M.	6	C
Apolitano, César	Peru	INIA		Plant breeding	Singh, S.	3	C
Mora, Bernardo	Costa Rica	Min. Agric. y Gan.		Plant Pathology	Pastor-C., M.	9	P
Hernández, Julio C.	Nicaragua	MIDINRA		Entomology	Schoonhoven, A.v.	5	C
Santacruz, Edgar	Colombia	FEDECAFE		Plant pathology	Pastor-C., M.	9	C
Pérez, Alfredo	Bolivia	Univ. Gabriel René Moreno		Plant breeding	Davis, J.	8	C
Parker, Jodi	USA	Univ. California		Interdisciplinary	Davis, J.	3	C
Haanschoten, Jaap	Holland	Univ. Florida		Soils microbiology	Schoonhoven, A.v.	6	C
Irastroza, María E.	Argentina	Univ. Cordoba		Seed Technology	Poey, F.	5	P

(Continued)

Table 8. (Continued)

Name	Country	Institution	Short course participants	Discipline	Supervisor	Months	Stage
Visiting researchers							
Herrera, Mario	Nicaragua	MIDINRA	N[c]	Plant physiology	de la Cruz, R.	3	C
Obando, Luis	Colombia	ICA	Y[d]	Plant breeding	Davis, J.	5	C
Soto, Nery Marco T.	Guatemala	ICTA	Y	Agronomy	Voysest, O.	5	C
Torres, Adolfo	Guatemala	ICTA	Y	Agronomy	Voysest, O.	5	C
Cáceres, Jacobo	Honduras	Ministerio de Rec. Naturales	Y	Plant pathology	Pastor-C., M.	4	C
Ortíz, Mariano	Peru	INIA	Y	Plant breeding	Davis, J.	5	C
Nieto, Bernardo	Peru	INIA	Y	Biometrics	Chapas, L.	4	C
Pérez, Héctor	Mexico	INIA	Y	Plant breeding	Singh, S.	2	C
Rodríguez, Federico	Honduras	Ministerio de Rec. Naturales	Y	Entomology	Cardona, C.	5	C
Herrera, Grace	Nicaragua	MIDINRA	N	Nutritional quality	Gómez, G.	1	C
Herrera, Gilda	Chile	INIA	N	Plant breeding	Dessert, M.	4	C
Schulz, Carlos	Paraguay	Min. Agric. y Gan.	N	Agronomy	Voysest, O.	2	C
Rizo, Ma. del Pilar	Nicaragua	MIDINRA	N	Germplasm-genetic resources	Roca, W.	2	C
Vaquedano, José L.	Honduras	Ministerio de	Y	Agronomy	Voysest, O.	6	C
Villacorta, Baltazar	El Salvador	CENTA	Y	Seeds	Poey, F.	3	C
Salvatierra, Jesús	Bolivia	Plan Desarural	Y	Agronomy	Voysest, O.	5	C
Moya, Jesús	Cuba	Min. Agricultura	Y	Agronomy	Voysest, O.	6	C
Obando, Ligia	Nicaragua	U. Nal. Autónoma	Y	Agronomy	Voysest, O.	6	C

(Continued)

Table 8. (Continued)

Name	Country	Institution	Short course participants	Discipline	Supervisor	Months	Stage
Short course participants							
Oliari, Lourenco	Brazil	IAPAR		Multidisciplinary	López, M. & staff	1	C
Valentini, Lucía	Brazil	Pesagro-Río		Multidisciplinary	López, M. & staff	1	C
Ponzelli, Pedro	Brazil	Inst. Agron. del *Estado de S.P.*		Multidisciplinary	López, M. & staff	1	C
Manrique, Roberto	Colombia	ICA		Multidisciplinary	López, M. & staff	1	C
Trinidad, Pedro	D. Republic	Secretaría de Estado de Agric.		Multidisciplinary	López, M. & staff	1	C
Sánchez Isaac	Mexico	INIA		Multidisciplinary	López, M. & staff	1	C
Quiroga, Roberto	Colombia	CVC		Multidisciplinary	López, M. & staff	1	C
Castaño, Héctor	Colombia	FEDECAFE		Multidisciplinary	López, M. & staff	1	C
Jaime, Zoila	Mexico	INIA		Multidisciplinary	López, M. & staff	1	C

a. C = completed.
b. P = in progress.
c. N = no.
d. Y = yes.

Personnel
(as of December 31, 1982)

PROGRAMA DE FRIJOL

Científicos principales
Aart van Schoonhoven, Ph.D., Entomólogo, Coordinador
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Jorge E. García, Ing. Agr., Entomología

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* Se retiró en 1982.
** En año sabático.

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* Se retiró en 1982.
** En año sabático.