Annual Report 1986

Bean Program

CIAT Centro Internacional de Agricultura Tropical

CONTENTS

THE BEAN PROGRAM

The principal bean producer is a small farmer with limited capital and little access to credit and extension information. Bean yields are low. The main factors responsible for the low yields are: the high disease and insect pressure from which the crop suffers; drought; low plant density (to reduce disease pressure); and farmers' reluctance to use inputs to avoid risk or due to lack of access to these inputs. The strategy followed by the Bean Program to increase yields and production is based upon three main activities :

1. Genetic improvement
2. Strengthening national programs
3. Basic research directed to problems of bean producers

Genetic improvement

Priority in genetic improvement is given to selection for more stable, higher-yielding beans, by developing multiple disease and pest resistant germplasm with increased tolerance to drought. Longer term objectives include: tolerance to moderately acid soils; improved genetic ability for symbiotic nitrogen fixation; and to increase yield potential. In summary, the bean program considers that the optimum way it can support national programs to achieve improved bean production is to assist them in developing improved varieties. Once superior, more stable yielding varieties are available, farmers are expected to respond with improved agronomy. The use of multiple disease resistant varieties with increased yield potential may form the third level of yield increase. The program develops scale neutral technology, with a bias toward small farmers.

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

The Bean Program, therefore, must genetically improve beans of different seed characteristics, for many cropping systems and ecological zones. Experience has shown that a decentralized breeding program, in which CIAT develops base populations with the national programs taking over the final development and promotion of new varieties, is the best strategy.

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

Genetic variability in beans is obtained from the 35,000 accessions in the germplasm bank held by the Genetic Resources Unit. Despite the size and representativeness of this collection, genetic variability for specific traits is often not expressed at sufficiently high levels to solve production constraints. Therefore, each breeder not only develops cultivars, but also cooperates with particular disciplines to develop maximum levels of character improvement (e.g., for bean golden mosaic virus (BGMV) resistance, drought tolerance, bacterial blight resistance, leafhopper tolerance, Ascochyta leafspot resistance, ability to fix nitrogen, high yield potential and, architectural traits). Lines with high levels of specific trait expressions are used to obtain multiple factor recombinants in the cultivar improvement activities.

National programs first relied primarily upon international yield trials (IBYANs) as sources of potential new cultivars. However, with increased ability to manage nurseries for selection at earlier stages, and with the recognition that local adaptation is highly desirable, most national programs now prefer to receive materials from the main CIAT nurseries (VEFs) or earlier generation materials (F_2 and onward) derived from crosses planned jointly by national programs and CIAT scientists.

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

From the above philosophy and practice, it is clear that the Bean Program strongly emphasizes varietal improvement, and considers that improved agronomic practices are best researched at the national program level and should be implemented when new varieties are available. Instrumental in this concept are the cropping systems agronomist (conducting on-farm research) and the economist, who together insure that breeders are familiar with the systems into which new varieties must fit, and that the necessary communication is maintained among farmers, extensionists and researchers. In addition, the cropping systems agronomist and economist develop methodologies of on-farm research which will help national programs identify agronomic practices suitable for new varieties in a given region.

Strengthening national programs

In conjunction with efforts in genetic improvement, the program has given high priority to helping bean producing countries develop strong bean programs. Greater self-reliance in research at the national program level is the eventual goal, since the diversity of cropping systems, production constraints and consumer requirements make it impossible for CIAT to attend all concerns.

Training offered by CIAT is either in research courses or in specialized scientist to scientist training through execution of joint research programs at CIAT. Increasingly, training is conducted in the national programs, with backup support from CIAT. The audiotutorial units, which pack information in cassette and slide shows, are particularly helpful in such efforts. Besides discipline oriented training, CIAT offers the option of conducting thesis research for advanced university degrees at headquarters. The results of training for self-reliance in research are becoming visible and show an evolution in the program's training strategy:

(1) Decentralized selection from the F_2 generation on is becoming increasingly important.
(2) CIAT-hosted courses are being replaced by in-country courses.
(3) The on-farm research concept is being developed through an intensive training effort, to ensure feedback to the research program and promote new technology via extension programs.

The Bean Program expects that through increased postgraduate training; growing experience; and developing research leadership, the national programs will develop to such a level that the bean research network becomes a mutually dependent collaborative research program. Such networks are composed of national programs which share similar ecological zones, wherein each national program specializes in certain research areas. Horizontal transfer among participating countries will ensure a complete research program, which can not be formed by each individual small program. This principle has proven most effective when many small national bean programs are involved. The network has traditionally been limited to Latin America, but network expansion to Africa has become an important activity since the first bean scientist was sent there in 1983. The formation of the integrated research network is enhanced by stationing CIAT staff in national programs to strengthen national research and stimulate regional collaboration. Four such networks are being formed: (1) Central America and the Caribbean; (2) the central African countries forming the Great Lakes Economic Community; (3) Eastern Africa; and, (4) Southern Africa.

Basic research applicable to bean production problems

As genetic improvement is being accomplished more and more at the national program level, CIAT has been giving greater emphasis to basic research activities aimed at facilitating genetic or agronomic improvement. Examples are the determination of mechanism and inheritance of observed resistances, improvements in research methodologies, and cropping system interaction studies. Such basic research is often conducted at CIAT with the help of graduate theses research, or in close collaboration with universities and other basic research centers, preferably in the developing world.

These strategies have proven to be effective in increasing bean production. Marked increases in bean production have taken place in certain regions and countries. Examples can be cited from Guatemala, Cuba, Costa Rica, Argentina, states of Brazil, and departments in Peru. These successes have strengthened the Bean Program's determination to continue to decentralize bean research and to increasingly assume a backup role to national research. Our role is shifting to the development and provision of genetic variability for local improvement programs; to provide training, develop methodology, and to offer basic research information.

HIGHLIGHTS 1986

The year 1986 has been again a very active year. In trying to summarize this, the best term may be "finetuning". Our objective of increased bean production was facilitated through our stress tolerance breeding strategy. Our decentralized system of genetic improvement places emphasis on training of national program staff. Finetuning of our research efforts was directed towards incorporating lacking resistance into superior lines while increasing our training efforts in the on-farm testing of new technology.

Program developments

Some changes in senior staffing took place during the year. Dr. Roger Kirkby (agronomist) joined CIAT as Coordinator of the Eastern Africa Project. He is based in Addis Ababa, Ethiopia. Dr. Joseph Thome (plant breeder) joined us as postdoctoral scientist to strengthen our effort in breeding for increased yield potential in beans.

Dr. George Abawi (Visiting Scientist in plant pathology, from Cornell University); Leif Youngdahl (Visiting Scientist in soil science, from the International Fertilizer Research and Development Center), Guillermo Hernandez Bravo (plant breeder, World Bank/INIPA Collaborative Bean Project, Peru) and Nigel R. Sackville-Hamilton (Senior Research Associate in plant breeding, Data Management Systems) left during the year.

Outposted staff and special projects

During 1986 the second of our three regional projects in Africa received funding and started formally. This project, the Eastern Africa Project, is funded jointly by USAID and CIDA for four scientists, and the agronomist-project leader is now installed in Ethiopia. Still to be recruited are a breeder and agronomist in Uganda and an economist to serve the African projects in general. Somalia also forms part of this project. A project establishment grant was provided by CIDA for the Southern African Project. The coordinator for this project is in place in its headquarters in Arusha, Tanzania. The additional staff is being recruited. The project covers the countries grouped in the SACAR agreement. The above three projects, including the already established Great Lakes project, form the CIAT outreach strategy for Africa for beans. An African-wide coordinator will be appointed.

The Great Lakes project and the Central American project were evaluated during 1986. Both evaluations were very positive. Research scientists and administrators of the Great Lakes project countries agreed that the project's main contribution was the additional genetic variability it had brought as well as the establishment of research links with neighboring countries.

During the evaluation of the Central American project it was agreed that the success of this project and the evolution of national programs warranted the establishment of a steering committee with wide administrative and managerial responsibilities. The management of this project will in the coming years be handed over to this committee composed of national bean team leaders. The impact the project has made on production of beans in Guatemala, Costa Rica and Cuba was documented.

A grant was obtained from DEGIS, Netherlands, to execute a study on snap beans, assessing consumption, demand, production problems and the social benefits of research. This follows a recommendation of the External Review Panel of CIAT. This two year study will be concluded by a large international snap bean conference.

The World Bank loan to finance a bean liaison scientist in Brazil was terminated. CIAT may absorb the costs in its core budget, by reducing its headquarters agronomy program and transferring the freed resources to finance this position in Brazil.

Several collaborative research projects were financed (to the outside collaborator) with institutions in the United States, England, Germany and Italy. Such projects help resolve basic research problems, which limit progress in our applied research task. Included in these projects is the third country quarantine service established with NVRS, England, to bring African bean germplasm to Colombia.

Research highlights

Germplasm Improvement

The high susceptibility of landraces to BCMV (especially red seeded early Central American criollos), has prevented their wide use in genetic improvement and production promotion. With the linkage broken between the I gene and unstable "off-color" reds, the I gene is now being incorporated in a wide range of landraces through backcrossing or a modified backcrossing scheme. The true red BCMV resistant landraces will be available for wide testing and use in breeding programs in early 1987.

Another aspect of "finetuning" of our genetic improvement activity is the improvement of newly released and successful varieties for deficiencies encountered. Some of these activities are the incorporation of anthracnose resistance in Talamanca, and CBB resistance in EMGOPA - Ouro; and in other lines, seed size has been increased (and CBB resistance incorporated) in excellent small seeded lines such as BAT -1297. The genetic improvement activities of the Bean Program emphasize both the development of entirely new germplasm, and also the improvement of superior new germplasm for specific weaknesses.

The External Review Panel recommended a further effort in increasing yield potential of beans. While a genetic improvement program is underway, agronomic studies were undertaken to accompany superior yielding germplasm by appropriate agronomic practices, such as split nitrogen applications and changes in plant density and rowspacings. Both increased plant density, and decreased row spacing, increased yields, but split N application in the first trial conducted did not increase yield.

In mutated populations, plants were selected which lacked the ability to fix nitrogen in N-free medium with high Rhizobium populations. Non-nodulating plants were identified which can serve as a zero level check for nitrogen fixation thereby eliminating the need to use non-fixing species such as sorghum as a check in bean trials. Also, plants from these same populations were selected with effective nodules under high nitrogen levels, to develop plants able to fix nitrogen in the presence of soil nitrogen. The presence of moderate levels of soil nitrogen inhibits nodulation, even when the soil nitrogen level is inadequate for normal plant development.

The high resistance in wild accessions of the common bean to the bruchid Zabrotes subfasciatus is due to the substitution of part of the phaseolin protein by a new protein, called arcelin. The presence of this protein is now being used as a rapid screening technique for Zabrotes subsfasciatus resistance. This research finding was obtained in a collaborative project with the University of Wisconsin. Other compounds that may be associated with resistance to Acanthoselides obtectus were found by TDRC, England.

The major part of the collection of Phaseolus coccineus has been evaluated and multiplied and an international coccineus trial was distributed to several countries. This germplasm may be used directly, besides as a donor parent to the common bean for breeding resistance. The multiplication of the collection of Phaseolus lunatus has been initiated.

The previously identified superior resistance to BGMV has been further exploited. Lines resulting from crosses involving these resistance sources (e.g. Garapato, A 429, DOR 303 and others) show high levels of BGMV resistance and good performance under high BGMV stress. However, such lines appear not to maintain their resistance to the Brazilian isolates of BGMV.

The race variability and its distribution for halo blight has been clarified through collaborative research with NVRS, England. Four races have been found, and parents have been identified to breed for resistance to this important African disease problem.

Training and workshops

Training remains our main activity after germplasm development.

A shift from CIAT-hosted courses to in-country courses has been reported before. Current emphasis in training is on on-farm research. The objective of this focus is to link research and extension, to test new technology on-farm prior to release and to increase perception of farmers' real problems by research staff. Of the 10 courses conducted (or CIAT supported) during 1986, seven concerned on-farm research. An important aspect of these courses is their three phases of execution. In each successive phase each of the participants reports the progress they made in their region, followed by a general discussion involving all participants. This follow-up of presentation of results by each participant has proven to be most useful.

One of the workshops conducted in CIAT involved breeders from various research stations in Mexico and their respective directors. Results of this workshop indicate that both researchers and research management gained a much better understanding of the possibilities and limitations of bean research. Researchers and administrators jointly evaluated research progress and methods and how to share this with farmers. Continued "finetuning" of training methodologies is under investigation to further improve the efficiency of our training efforts.

Varietal release and adoption

New varieties were released by national programs during 1986. ICTA-Ostua (JU 81-53) was released as a BGMV tolerant line in Guatemala. The purpose of its development and release was to provide earlier maturing, BGMV tolerant lines better than the previous ICTA releases.

Costa Rica released the locally developed line HT-7719 as Cariari. The line was released for its tolerance to web blight. Brazil released BAT-48 as Sobradinho. Peru released Panamita Molinero (line W 126 from MITA, Puerto Rico). Rwanda released A 197 as Ikinyange.

Based on farm surveys it is estimated that the ICTA varieties have contributed to an increased production valued in 1985 at $US 2.06 million in Guatemala, while new varieties have increased production in Costa Rica about $US 2.7 million and far more in Argentina.

Lack of seed of new varieties has been shown to often be a major bottle neck to increased adoption of new varieties. On-farm seed production methods are being promoted, in collaboration with the Seed Unit. Some very promising developments are taking place in Colombia, where small local cooperatives are involved in seed production for its members. One such cooperative in San Gil, Santander, produced over 20 tons of seed. A similar program is being initiated in Guatemala.

Bean program impact

National programs have released over 100 improved bean varieties obtained through the CIAT network, and in several countries new bean varieties have been widely adopted. Surveys of bean farmers have been conducted to measure the adoption and impact of new varieties in Argentina, Costa Rica, Guatemala and Nicaragua. These results are summarized in Table 1. (details on survey results are contained in this year's and previous Annual Reports as well as in outside publications).

In 1986 an estimated 154,000 ha were sown to new bean varieties derived from CIAT germplasm. The total production of these varieties was 186,800 tons, and the increased output due to the new varieties'greater productivity than traditional materials was 49,400 tons. The gross value of production of the improved varieties was $93,400,000 ($U.S. 1985), while the value of the additional output due to the new varieties over what could have been produced with traditional varieties in 1986 was $24,700,000.

This sum is nearly four times the 1986 CIAT expenditures on bean research, including both direct program costs and a prorated share of non-program costs. Of course, national program efforts are a vital part of the success acheved so far with new bean varieties. Arbitrarily assigning to CIAT and national programs an equal share of the gross benefits due to the improved bean varieties, the net benefits (gross benefits - investment costs) of CIAT bean research are presented in Figure 1. This shows a period of increasing real net investment from 1973 to 1979. From 1979 onwards the benefits of the new varieties begin to accrue, and from 1983 onwards the program entered a period of substantial and increasing positive net benefits, reaching $5.9 million in 1986.

Table 1. Impact of improved bean varieties, 1986.

	Area in improved varieties (ha)	Per cent area in improved varieties	Production of improved varieties (tons)	Production increase due to improved varieties (tons)
Costa Rica	21,700	62	18,900	5,300
Guatemala	12,300	13	11,700	4,100
Nicaragua	14,000	17	11,200	2,800
Cuba	16,000	80	25,000	11,200
Argentina	90,000	40	120,000	26,000
TOTAL	154,000		186,800	49,400

Source : Farm surveys in Argentina, Costa Rica, Guatemala, Nicaragua; National program estimates in Cuba and Nicaragua.

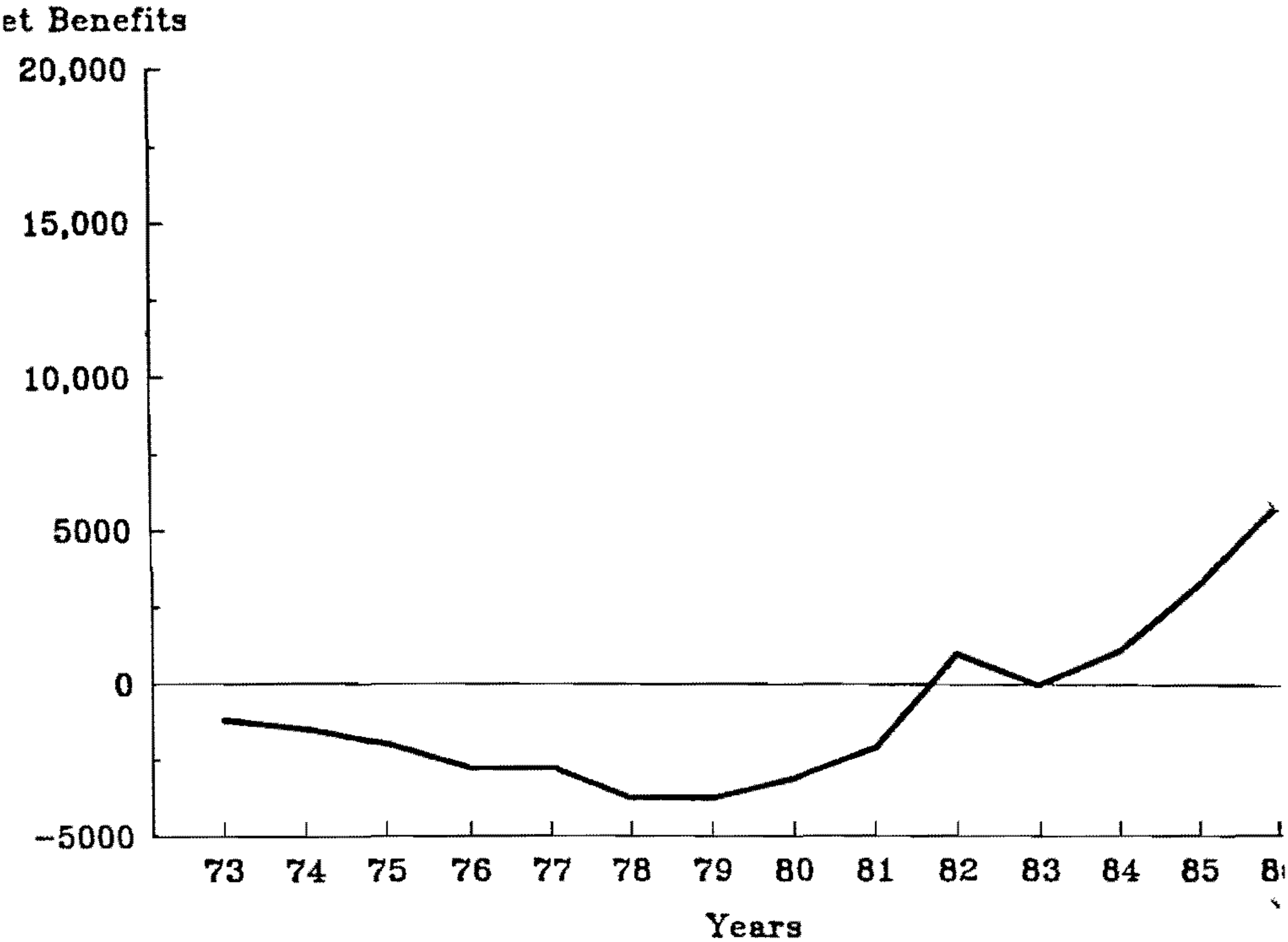


FIGURE 1. NET BENEFITS OF CIAT BEAN PROGRAM 1973-1986 (1985 $US x 10^3)

TRAINING

Introduction

Training of scientists and extensionists at CIAT headquarters in the development, testing and promotion of new breeding lines and agronomic practices continued to receive high priority in the Bean Program. Emphasis in 1986, however concentrated on providing scientists with training in on-farm research, both at headquarters and in participating countries.

On-farm research is a basic step in the accurate identification of specific local production problems. Research accomplished on-farm in each region within the Bean Program's mandate will continue to provide crucial information on existent constraints; the availability of alternative technologies; and on which available or new technologies need more testing or validation. On-farm research helps determine what germplasm improvement strategy to employ, as well as to discover what technical training would most appropriately meet local needs.

Germplasm developed on experimental stations is not ready for release until its adaptability and yield potential for a target area has been proved through on-farm trials in existing cropping systems. If new material fulfills these basic requirements, and the farmers feel it is better material than that currently used, the new technology is released by that country's national program.

The manner in which new germplasm is carefully tested prior to release is paralleled by the equal careful training provided to scientists from around the world.

Courses

Ten in-country courses were conducted with the collaboration of national programs in 1986, and seven of these concentrated on on-farm research methologies. These courses provided training for 157 scientists from El Salvador, Costa Rica, Nicaragua, Peru and Honduras (Table 1). Another 23 scientists or extensionists from various countries received training in on-farm research at CIAT headquarters in Palmira, Colombia (Table 2). A total of 180 persons were trained this year by CIAT and collaborating institutions in on-farm research.

Courses are designed to prepare the trainees in the following manner:

a. The varying backgrounds of the trainees are used to divide them into four groups:a) Focused - those who are already interested in the stated objectives of the course; 2) Ambitious - those who have interest but lack background preparation; 3) Non-focused - those who have little interest in the course objectives; 4) Non-motivated - those who have little interest and no background preparation.

b. Initial evaluations are given to help the participants identify those areas in which they most need training. The trainees can then concentrate on these themes during the course.

c. Intermediate evaluations are given to maintain adequate academic levels in the courses, and are used to determine the level of participation and understanding given to or received from the course.

d. Courses are oriented towards providing continuity with future activities. These activities may include further training in courses or actual research at CIAT headquarters or in the trainees' own countries.

e. Participants evaluate the courses as to whether or not they met their expectations. Their negative and positive criticisms are invaluable to course designers for the planning of future courses.

Training in specific disciplines

Training in specific disciplines is conducted at CIAT headquarters. In 1986, 76 scientists from the Americas, Europe, Asia and Africa received training in various disciplines (Tables 2, 3 and 4). The discipline attracting the greatest number of participants (22) was on-farm research.

CIAT also hosted the XIII Intensive Multidisciplinary Course for Bean Research and Production, with 23 participants (Table 1).

Workshops

A workshop was held April 21-25 on Routine Evaluation Methodologies for Bean Acceptability Characteristics. Representatives from El Salvador (CENTA), Cuba (Ministerio de la Agricultura), Guatemala (INCAP), and Costa Rica (INCIENSA) attended this workshop.

A Bean Breeding Workshop was held 9-17 June, and was attended by 17 scientist from INIFAP in Mexico.

An On-Farm Research Workshop was held 15-19 September, with 20 scientists and extensionists from ICA-Colombia in attendance.

Other training

The training provided by CIAT and participating national programs in 1986 has contributed greatly to the strengthening of the bean research network in several ways. The level of scientific expertise in national institutions is further improved by the assistance offered by CIAT to staff members from various countries in their Masters and PhD research projects. (Table 2). CIAT gives support to national training efforts by assisting at in-country courses - 204 persons received training in their own countries this year.

The emphasis placed on on-farm research in 1986 resulted in the training of 179 scientists and extensionists. The strong addition of trained on-farm investigators will strengthen the bean research network in all participating institutions.

Table 1. Courses given in 1986

Course Type	Country	Collaborating Institution	Number of Participants
Research and production	Cuba	Min. of Agriculture	30
On-farm research (I phase)	El Salvador	CENTA	13
On-farm research (I phase)	Costa Rica	U. of C. R. MAG, CNP, ONS	28
On-farm research (I phase)	Nicaragua	MIDINRA	23
On-farm research (III phase)	Peru	INIPA	26
On-farm research (I phase)	Honduras	Sec. Natural Resources	29
Research	Mexico	INIFAP	17
On-farm research (II phase)	El Salvador	CENTA	10
On-farm research (II phase)	Nicaragua	MIDINRA	28
Research and production (XIII (Intensive phase)	Colombia	International	23
		TOTAL	227

Table 2. Training provided at CIAT in specific disciplines.

	Training Category															
	Visiting Associate				Visiting Scientist						Student					
Program : Bean	THESIS PHD		NO THESIS		THESIS MS		Training in Special Discipline		Special Training + Multidisciplinary Course						SUBTOTALS	
	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months
Discipline:																
Agronomy							5	(16.3)	6	(28.8)	1	(11.2)			12	(56.3)
Economics					1	(9.1)	2	(15.8)							3	(24.9)
Entomology							3	(10.2)	1	(5.0)					4	(15.2)
Farming Systems							19	(33.0)	3	(8.2)					22	(41.2)
Physiology									1	(1.6)					1	(1.6)
Breeding	1	(12.0)	1	(12.0)	1	(5.8)	1	(3.1)							4	(32.9)
Phytopathology							3	(12.8)							3	(12.8)
Germplasm							1	(3.1)							1	(3.1)
Laboratory							1	(0.3)							1	(0.3)
Breeding							4	(12.2)							4	(12.2)
Micorrhiza							1	(1.0)							1	(1.0)
Pathology							6	(10.8)	4	(14.5)	1	(4.9)			11	(30.2)
Production													8	(8.9)	8	(8.9)
Virology							1	(1.6)							1	(1.6)
Program total	1	(12.0)	1	(12.0)	2	(14.9)	47	(120.2)	15	(58.1)	2	(16.1)	8	(8.9)	76	(242.2)

Table 3. Number of man-months of training provided by CIAT, by country, in 1986.

Program : Bean	Training Category															
	Visiting Associate				Visiting Scientist						Student					
	THESIS PHD		NO THESIS		THESIS MS		Training in Special Discipline		Special Training + Multidisciplinary Course						SUBTOTALS	
	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months
Latin America and the Caribbean																
Argentina							2	(5.0)							2	(5.0)
Bolivia									1	(5.1)					1	(5.1)
Brazil							1	(4.0)							1	(4.0)
Colombia							14	(24.2)					4	(4.4)	18	(28.6)
Costa Rica							2	(6.9)	3	(10.5)					5	(17.4)
Cuba							2	(5.9)							2	(5.9)
Ecuador									1	(2.8)			1	(1.1)	2	(3.9)
El Salvador							2	(5.6)							2	(5.6)
Guatemala					1	(5.8)	3	(7.7)	3	(15.0)	1	(4.9)			8	(33.4)
Haiti									1	(3.9)					1	(3.9)
Honduras							2	(6.8)							2	(6.8)
Mexico							1	(1.7)	3	(5.9)			2	(2.3)	6	(9.9)
Nicaragua							1	(4.2)	1	(4.8)			1	(1.1)	3	(10.11)
Panama											1	(11.2)			1	(11.2)
Peru							6	(12.9)	1	(5.1)					7	(18.0)
Dominican Republic							3	(2.3)	1	(5.0)					4	(7.3)
Other Countries																
Asia																
Philippines							1	(3.2)							1	(3.2)
Africa																
Ethiopia							1	(1.9)							1	(1.9)
Tanzania							1	(1.9)							1	(1.9)
Uganda							1	(3.0)							1	(3.0)
Zaire							2	(5.5)							2	(5.5)
Developed Countries																
Germany	1	(12.0)													1	(12.0)
Belgium			1	(12.0)											1	(12.0)
Canada					1	(9.1)									1	(9.1)
U S A							1	(5.5)							1	(5.5)
Holland							1	(12.0)							1	(12.0)
Program total	1	(12.0)	1	(12.0)	2	(14.9)	47	(120.2)	15	(58.1)	2	(16.1)	8	(8.9)	76	(242.2)

Table 4. Bean Program

NAME		COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN - MONTHS AT CIAT
Visiting Research Associates, No Thesis						
Schmit	Veronique	Belgium	Univ. of Gembloux	Breeding	Davis J.	12
Visiting Research Associates, PhD Thesis						
Panse	Axel	Germany	Univ. Friedrich Wilhelm	Breeding	Davis J.	12
Participants in Phase I of Intensive Multidisciplinary Course						
Alacaraz M.	Sandra	Colombia	CIAT	Production	Lopez M.	1.1
Aragon C	Jose Javier	Colombia	ICA	Production	Lopez M.	1.1
Camacho	Alberto	Nicaragua	Mindinra	Production	Lopez M.	1.1
Cazares E.	Benito	Mexico	INIFAP	Production	Lopez M.	1.1
Gonzãles M.	Alonso	Colombia	CIAT	Production	Lopez M.	1.1
Ligarreto M.	Gustavo A	Colombia	INCA	Production	Lopez M.	1.1
Salgado S.	Ernesto	Mexico	INIFAP	Production	Lopez M.	1.2
Zambrano M	Ely	Ecuador	INIAP	Production	Lopez M.	1.1.

Continued

Table 4. (Continuation)

NAME	COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN—MONTHS AT CIAT
Visiting Scientists					
Adames M. Cristôbal	Dominican Rep.	SEA	Pathology	Gálvez G.	1
Amaro G. Carmen	Cuba	Ministerio de Agricultura	Phytopathology	Pastor C. M.	3.3
Araya F Carlos Manuel	Costa Rica	Universidad Nacional	Pathology	Pastos C. M.	4.9
Arias R. Jesus H.	Colombia	ICA	Farming Systems	Woolley J.	1.7
Assefa Habtu	Ethiopia	Inst. of Agricultural Research	Pathology	Pastor C. M.	1.9
Benavides M Rolando	Nicaragua	Mindira	Agronomy	Voysest O.	4.8
Camacho B Willy	Costa Rica	Consejo Nacional de Producción	Agronomy	Voysest O.	3.8
Chumbiacua R Luis Alberto	Peru	INIPA	Virology	Morales F.	1.6
Cucalón S Hernando	Colombia	CVC	Farming Systems	Woolley J.	1.7
Díaz A Oswaldo Fidél	Honduras	Secretaría de Recursos Naturales	Entomology	Cardona C.	3.1
Díaz Acosta Jose Manuel	Cuba	Empresa Arrocera Los Palacios	Agronomy	Voysest O.	2.6
Díaz C Hector A	Guatemala	ICTA	Entomology	Cardona C.	5
García M. Aurora S.	Argentina	INTA	Breeding	Singh S.	2.9
García P. Eddy A.	Nicaragua	Midinra	Entomology	Cardona C.	4.2
Gordon G. Juán José	Guatemala	ICTA	Agronomy	Voysest O	5
Hernandez Hugo	Costa Rica	Universidad de Costa Rica	Farming Systems	Woolley J.	2.8
Herrera R. Miguel Amaury	Dominican Rep.	SEA	Pathology	Galvez G.	1
Insuasty B Orlando I	Colombia	ICA	Farming Systems	Woolley J.	1.7
Jimenez de Nelly	Peru	U. Nal. Pedro Ruiz Gallo	Micorrhiza	Sieverding E.	1
Jimenez T. Jose A.	Honduras	Secretaria de Recursos Naturales	Breeding	Beebe S.	3.7
Lanter J. Marie	U S A	Univ. of California	Phytopathology	Pastor C M	5.5

Continued

Table 4. (Continuation)

NAME		COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN—MONTHS AT CIAT
Lilián J.	Jorge Hernan	Peru	INIPA	Germplasm	Wodd D.	3.1
Loayza C.	Romulo F.	Peru	INIPA	Agronomy	Voysest O.	3.8
Lopez A.	Beatriz	Mexico	INIFAP	Pathology	Pastor C. M.	1.7
Lugo C.	Jaime	Colombia	ICA	Farming Systems	Woolley J.	1.7
Luna de P.	Luz alba	Colombia	ICA	Farming Systems	Woolley J.	1.7
M'Vita	Bambi	Zaire	R. A. V./Prog. National Leg.	Breeding	Davis J.	2.6
Maghirang	Rodel	Philippines	Inst. of Breeding	Agronomy	Voysest O.	3.2
Male Kayima	Beatrice	Uganda	Kawanda Research Station	Breeding	Davis J.	3
Medina G.	Juan A.	Guatemala	ICTA	Pathology	Pastor C. M.	3.8
Menendez C	Raul	Guatemala	ICTA	Pathology	Galvez G.	1
Merino P	Fausto Ivan	Ecuador	INIAP	Farming Systems	Woolley J.	2.8
Meza Q.	Jorge Hernán	Colombia	ICA	Farming Systems	Woolley J.	1.7
Milfort	Brefous	Haiti	Fac. Agron. y Med. Veterinaria	Agronomy	Voysest O.	3.9
Miranda L	Diego	Colombia	ICA	Farming Systems	Woolley J.	1.7
Molina O.	Juan Pablo	Peru	INIPA	Farming Systems	Woolley J.	1.8
Monsalve U.	Orlando	Colombia	ICA	Farming Systems	Woolley J.	1.8
Montenegro M	Tito	El Salvador	CENTA	Economics	Pachico D.	3.8
Monzon Q.	Felicito Amado	Guatemala	ICTA	Entomology	Cardona C.	2.9
Navarro	Willy	Costa Rica	Universidad Nacional	Breeding	Roca-Davis	3.1
Nin	Julio Cesar	Dominican Rep.	SEA	Agronomy	Voysest O.	5
Ochoa O.	Hector E.	Guatemala	ICTA	Agronomy	Voysest O.	5
Oliveira E.	Silva Leandro	Brazil	EMGOPA	Phytopathology	Singh S.	4
Orube F.	Juan B.	Bolivia	Univ. Gabriel R. Moreno	Agronomy	Voysest O.	5.1
Pajarito R.	Arnulfo	Mexico	INIFAP	Physiology	White J.	1.6
Perez S.	Marilyn Amelia	Dominican Rep.	Secretaria de Estado de Agr.	Laboratories	Schoonhoven	0.3

Continued

Table 4. (Continuation)

NAME		COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN—MONTHS AT CIAT
Pibuya O.	Stephen	Tanzania	Agricul. Research Organization	Farming Systems	Woolley J.	1.9
Prada L.	Pedro Cesar	Colombia	ICA	Farming Systems	Woolley J.	1.7
Rios G.	Germán	Colombia	ICA	Farming Systems	Woolley J.	1.8
Rojas J.	Maria del R.	Costa Rica	IICA	Pathology	Abawi G.	2.8
Segovia S.	José Rafael	Colombia	ICA	Farming Systems	Woolley J.	1.7
Serrabi G.	Ernesto	Colombia	ICA	Farming Systems	Woolley J.	1.7
Sosa Moran	Jose H.	El Salvador	CENTA	Farming Systems	Woolley J.	1.8
Terrones C.	Segundo	Peru	INIPA	Pathology	Pastor C. M.	5.1
Van Herpen	Catharina	Holland	University of Wageningen	Economics	Pachico D.	12
Velasquez C.	Ricardo	Colombia	ICA	Farming Systems	Woolley J.	1.8
Vidal P.	Alberto	Peru	Centro de Invest. y Promoc. Agr.	Farming Systems	Woolley J.	1.6
Villamizar	Jaime	Colombia	ICA	Farming Systems	Woolley J.	1.8
Villar S.	Bernardo	Mexico	INIFAP	Farming Systems	Woolley J.	2.6
Vizgarra	Oscar N	Argentina	Estación Experimental Obispo C.	Pathology	Pastor C. M.	2.1
Wa Nyembo	Mwyumba	Zaire	Project de Rech. Agron. Ap.Et V.	Agronomy	Voysest O.	2.9

Visiting Scientists, MS Thesis

NAME		COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN—MONTHS AT CIAT
Acosta N.	Miguel A.	Panama	IDIAP	Agronomy	Voysest O.	11.2
Anderson	Marina	Canada	Univ. of Alberta	Economics	Pachico D.	9.1 C
Guzman A.	Marcial E.	Guatemala	ICTA	Pathology	Pastor C.M.	4.9
Rodriguez	Rafael	Guatemala	ICTA	Breeding	Beebe S.	5.8 C

I. BEAN GERMPLASM ACTIVITIES

A. Germplasm Collection, Multiplication and Distribution

Acquisition

Emphasis on the acquisition of *Phaseolus* germplasm has continued to be directed to land races and wild species. In addition to intensive expeditionary work in Latin America, several interesting materials from Europe, Asia, and Africa were received mainly from multicrop collecting expeditions funded by IBPGR, and also through donations from national banks.

Worth special mention were donations from several European countries. The Democratic Republic of Germany sent a set of about 100 traditional landraces collected in the Republic of Georgia (Soviet Union). Bulgaria also sent more than 60 accessions comprised mostly of native landraces. Italy donated about 250 accessions from its national bank at Bari. Finally, Turkey sent 117 accessions of their national collection at Izmir, complementing Turkish germplasm already received by CIAT from other banks. Also of special interest is germplasm received from Rwanda (270 accessions) via Belgium, which served as a third country quarantine. These accessions make up the traditional germplasm collected in 1985-86. In addition, a number of different species collected in Mexico, Guatemala, and Argentina has widened the spectrum of germplasm variability now represented in the bank for the genus.

Excluding the germplasm collected by the CIAT-IBPGR specialized collector, the bank received through donations a total of 1498 materials distributed as follows: 1077 accessions of *P. vulgaris*; 174 of *P. lunatus*; 16 of *P. coccineus*; 4 of *P. acutifolius*; 46 of wild *Phaseolus* species; and, 181 accessions of other genera mainly consisting of *Vigna* sp. (Table 1). The CIAT collector obtained a total of 474 materials from Guatemala, Argentina and Mexico. A total of 1972 accessions from donations and collecting expeditions were introduced to the germplasm bank in 1986 (Table 2).

Increase-Multiplication

Of the last batch of 6000 new accessions approved by ICA for multiplication in CIAT greenhouses and isolated fields, about 1100 materials were multiplied from 23 countries; the highest percentage of these came from USA, Peru, and Rwanda (Table 3). 1278 materials were rejuvenated.

These additions included, the germplasm currently available for distribution is as follows: 19,905 accessions of *P. vulgaris* and wild ancestral species; 842 accessions of *P. lunatus*; 644 accessions of *P. coccineus* and 168 accessions of *P. acutifolius*.

Table 1. *Phaseolus* introduction: bean germplasm introduced during 1986.

Region/Country	P. vulg	P. lun.	P. coc.	P. acut	Wild sp.	Others
North America						
USA	3	-	-	-	-	-
Central America						
Mexico (a)	30	-	15	-	57	-
Guatemala (a)	12	-	45	-	34	-
Nicaragua	8	-	-	1	-	-
Costa Rica	69	-	-	2	-	-
Caribbean						
Belize	-	-	-	-	3	-
Dominican Rep.	4	-	-	-	-	-
Puerto Rico	4	-	-	-	-	-
Andean South America						
Colombia	15	1	1	-	3	-
Ecuador	3	-	-	-	-	-
Peru (a)	174	46	7	-	8	2
Chile	-	1	1	-	-	-
Non-Andean South America						
Brazil	19	152	-	-	-	-
Argentina(a)	95	-	-	-	16	-
Europe						
England	41	-	-	-	-	-
Italy	224	-	13	-	-	15
Belgium	-	-	-	1	40	-
Netherlands	3	-	-	-	-	-
Bulgaria	63	-	-	-	-	-
Austria	28	-	1	-	-	1
Germany Dem.	97	-	-	-	-	-
Africa						
Ghana (b)	-	19	-	-	-	-
Zambia (b)	28	-	-	-	-	-
Madagascar (b)	15	-	-	-	-	-
Mauritius Isl. (b)	1	-	-	-	-	-
Rwanda	270	-	-	-	-	-
Asia Oceania						
Bangladesh	-	-	-	-	-	163
Turkey	117	-	-	-	-	-
Philippines	-	1	-	-	-	-
Total	1323	220	83	4	161	181

(a) Co-sponsored by CIAT-IBPGR
(b) IBPGR collecting expeditions

Table 2. Status of the bean collection held at the CIAT Genetic Resources Unit as of December 1986.

Species	No. of accessions Introduced	Increased
P. vulgaris	32942	19905
P. vulgaris wild ancestors	383	346
P. lunatus	2715	842
P. lunatus wild ancestors	63	40
P. coccineus subsp. *coccineus*	838	387
P. coccineus subsp. *polyanthus*	416	238
P. coccineus wild ancestors	68	19
P. acutifolius	138	116
P. acutifolius wild ancestors	50	50
Wild non-cultivated		
P. angustissimus, *P. anisotrichus*, *P. esperanzae*, *P. filiformis*, *P. glaucocarpus*, *P. galactoides*, *P. glabellus*, *P. grayanus*, *P. jaliscanus*, *P. macrocarpus*, *P. metcalfei*, *P. pedicellatus*, *P. polystachius*, *P. pluriflorus*, *P. pachirrhizoides*, *P. parvulus*, *P. ritensis*, *P. tuerckheimii*, *P. wrightii*, *P. anahuacensis*, *P. floribundus*, *P. neglectus*, *P. glaucocarpus*, *P. escabrellus*, *P. xanthotrichus*	248	41
TOTAL	37861	21984

Table 3. Country distribution of new *Phaseolus* germplasm multiplied and/or regenerated in CIAT's greenhouse during 1986.

Region and Country	No. of accessions
North America	
U.S.A.	891
Central America	
Costa Rica	2
El Salvador	7
Guatemala	67
Honduras	2
Mexico	87
Nicaragua	11
Panama	4
Caribbean	
Cuba	11
Dominican Republic	7
Puerto Rico	19
Andean South America	
Chile	78
Peru	688
Venezuela	5
Non-Andean South America	
Argentina	19
Brazil	34
Europe	
Austria	28
Belgium	25
Bulgaria	17
England	92
France	2
Netherlands	12
Africa	
Rwanda	270
Total	2378

Characterization

Characterization of germplasm using the descriptors proposed by CIAT has continued in 1986. Medium seeded types of growth habits I, II, and III were characterized with the goal of detecting similar groups of germplasm. The first analysis of 752 accessions of large seeded types with uniform color and growth habit I showed that the quantity of materials can be reduced by characterization to 290 groups (Table 4). The components of each group are very similar based on 14 field descriptors and 4 seed descriptors. It was observed that if seed descriptors are precisely defined, the groups chosen on these seed descriptor bases, correlate very well with the groups subsequently chosen by field descriptors. The next step will be to compare the components of each group using seed protein electrophoretic banding. Complete characterization is expected to provide a better comprehensive view of the true variability of the world *Phaseolus vulgaris* collection, and to establish grounds for tracing the path of germplasm exchanges among national collections.

Table 4. Grouping of similar *P. vulgaris* germplasm of growth habit I and large seeded type.

Seedcoat color	No. of accessions	No. of similar groups
White	209	41
Cream-beige	67	51
Yellow	167	56
Brown	27	12
Pink	60	20
Red	82	40
Purple	109	46
Black	31	24
TOTAL	752	290

Table 5. Bean seed distribution outside CIAT (1986)

Region	No. of countries	No. of requests	No. of accessions
North America	2	12	408
Central America	2	7	1127
Caribbean	1	1	6
Andean South America	4	18	1139
Non-Andean South America	2	10	1479
Europe	8	10	425
Africa	5	7	1702
Asia-Oceania	2	2	423
Total	23	67	6709

Table 6. Bean seed distribution within CIAT (1986)

Program	No. of requests	No. of accessions
Breeding I	11	57
Breeding II	14	206
Breeding III	24	1757
Agronomy	1	1
Entomology	31	4917
Physiology	18	2742
Pathology	10	447
Virology	16	1530
Nutrition	3	157
Biotechnology	8	355
Others	3	5
Total	139	12174

Storage

As part of the agreement with EMBRAPA, a duplicate of the base collection for preservation in long term storage (2000 accessions), was sent to CENARGEN this year. Each sample consisted of 400 grs of fresh and high quality seed which had been previously dried down to 6-8% moisture content before being packaged in laminated foil bags and heat sealed.

Ten percent of this batch was tested for germination as well as for seed moisture content before packing; the results showed an average 6.8% seed moisture content and 94% germination for 220 accessions. Besides the 2000 accessions for storage, four additional replicates of the 220 tested accessions were also sent in order to monitor germination and seed moisture content at least every five years. Shipments of about 4000 accessions per year will be sent until an entire duplicate of the collection is stored in CENARGEN's bank.

Funding was approved this year for the expansion of the present storing facilities. A new building capable of storing 100,000 accessions for short to medium-term storage, and 100,000 accessions for long term storage, will be constructed during 1987. This building will be able to hold the *Phaseolus* beans collection, as well as the tropical pastures collection, and the *in vitro* cassava collection.

Seed distribution service

During 1986 a total of 6709 accessions of *Phaseolus* beans were distributed to 23 countries in 67 shipments. Most of this germplasm consisted of *P. vulgaris* (80%), followed by *P. coccineus* (7%), *P. acutifolius* (3.5%), *P. lunatus* (1%) and the rest of other species (Table 5). In addition, the Bean Program in 1986 requested 14,546 accessions of which 91% were domesticated forms of *P. vulgaris*, 5% of wild ancestral forms of *P. vulgaris*, 3% of *P. coccineus* and almost 1% of *P. acutifolius* (Table 6).

Collection

The Genetic Resources Unit continued its program of germplasm collection and study of genetic diversity in the three American centers of diversification of *Phaseolus*. In order to provide a service to breeders and agronomists on a worldwide basis, germplasm collection concentrated on old native varieties of the five cultivated species developed by the American Indian cultures, the wild ancestors of the five cultivated species, and the true wild species.

Four collection trips were carried out during 1986, of which the results and outstanding conclusions are presented. This activity is a collaborative CIAT-IBPGR program.

GUATEMALA

A collection trip was made in the western part of Guatemala to collect germplasm of cultivated P. coccineus and P. polyanthus. Materials collected are listed in Table 7.

Of the 88 materials, P. macrolepis and P. xanthotrichus were collected for the first time. P. polyanthus was found as a wild ancestor, indicating that the cultigen is the fifth true cultivated species. P. tuerckheimii was also found during this trip and germplasm collected subsequently.

ARGENTINA

A collection trip was carried out in the northwestern part of Argentina to establish the representation of that region in CIAT's common bean collection (Table 7). Four collections of P. augusti has made this germplasm available for the first time.

PERU

A morpho-agronomic evaluation was performed on the 573 landraces of P. vulgaris collected in 1985, to establish where variability was concentrated. A complementary collection trip was carried out in northern Peru, where both cultivated and wild species were collected (Table 7), as well as native varieties of lima bean.

This second exploration confirms Cajamarca and Amazonas as a transition area between the North Andean Center and the South Andean Center, as shown especially by the distribution of ñuñas, P. polyanthus and P. pachyrrhizoides. The presence of wild forms of P. vulgaris and P. lunatus in intermontane valleys close to the Peruvian coast, as well as the presence of weedy types, shed new light on the domestication of beans in Peru, and on the use of this germplasm in breeding.

MEXICO

Germplasm of the P. pedicellatus group was almost non-existant in germplasm banks, limiting study and use of this group in breeding. An exploration was carried out in northeastern Mexico to improve this situation, and to collect other wild species (Table 7).

These 73 samples include the type specimens for P. floribundus, P. polymorphus and P. xanthotrichus v. zimapanensis. The presence of wild P. vulgaris in the Sierra Madre Oriental, not previously reported, opens new prospects for further exploration, use in breeding and a better understanding of the evolution of this crop. Germplasm is now available for the very poorly known species of the P. neglectus group.

Conclusions

1) 467 samples were collected this year, resulting in the availability of germplasm for 24 different taxa. For 12 taxa, germplasm

was collected for the first time. As a consequence of these explorations, germplasm is now available for 31 out of 56 species belonging to *Phaseolus* (although sometimes just a very few samples).

2) Genetic erosion is severe in several places of western and central Guatemala, central and northern Mexico, northern Peru, and northwestern Argentina, due to overgrazing and/or urban growth. A list of sites can be drawn up for *in situ* conservation for the type or most representative specimens.

3) The present list of species is still a provisional one: new materials were found in Mexico and in Guatemala. Our knowledge about the distribution of each species has improved considerably because of samples found this year. For instance, information on the distribution of wild *P. vulgaris* in Mexico and Peru, should help indicate how these regions contribute to the different gene pools.

Future plans: collection and research

A tentative schedule for specific and complementary germplasm exploration and collection in 1987 will emphasize the following:

- Costa Rica : mainly for bean germplasm grown on acid soils and in zones of high web blight pressure, plus wild ancestors.

- Guatemala: Mayan varieties of lima beans, tropical tepary germplasm, and wild species.

- Peru: wild forms of *P. vulgaris* and *P. lunatus* and wild species.

- Mexico: wild ancestral forms of the cultigens and wild species.

In addition, a revision of the status of the *Phaseolus* germplasm for several African countries will be carried out to facilitate planning future field work.

The collaborative project between CIAT and the Faculty of Gembloux (Belgium), was expanded to include the evaluation and multiplication of the *P. lunatus* collection held at CIAT. Planned future activities within this project are:

- Seed multiplication of the entire collection, while avoiding outcrossing.

- Morpho-agronomic evaluation especially for yield and adaptation.

- Production of a catalogue.

Priority was given to seed multiplication of accessions with very old seeds or seeds which have not been multiplied. Also of particular importance were studies to estimate the outcrossing rate of *P. lunatus* in different environments.

Passport data are urgently needed to evaluate the representativeness of our collection, to eliminate duplicates and to identify areas for future collection. The 966 accessions without origin (39% of the collection) obtained principally from IITA in Nigeria, will receive priority in this undertaking.

Seed multiplication of the accessions is done principally in a meshhouse at CIAT/Palmira. This meshhouse permits a maximum multiplication of 400 accessions per year. A total of 448 accessions are currently in multiplication (306 at Palmira and 142 at Popayan in the field).

During the seed increase, a preliminary morphological evaluation is conducted. Data include pilosity of the outer face of the standard, degree of the opening of the wing, and color pattern of flowers, pods and seeds. These data describe the variability of the germplasm, and should help identify the presence of genetic markers.

A wide range of variability has been observed for seed coat color, pod curvature and flowering time. Most of the accessions in multiplication have indeterminate growth habit. A base stock of at least 200 seeds for each accession is desired to lessen the risk of outcrossing in the field. A total of 38 accessions of the 448 currently in multiplication, possess this base stock of seeds. The "Big Lima" cultigroup present a particular problem as seeds germinate even before maturity. A study will be carried out to determine ecological factors causing this problem.

A field trial was set up at three locations (Palmira, Dagua and Popayan), to estimate the outcrossing rate of P. lunatus. Two dominant characters, three varieties, and different planting distances from the donor parent were used. The cultigroups "Big Lima" and "Sieva" which are more important in the P. lunatus germplasm were used in this study. The F_1 has been sown at Palmira and the first evaluation will be made on the hypocotyl color (for "Sieva") or on the indeterminate growth habit (for "Big Lima"). Repeats of this trial are planned for several seasons.

A preliminary agronomic evaluation will be started in different locales with already multiplied accessions having clear origins. This trial may include 100 to 150 accessions and will be planted at Palmira and Dagua.

Table 7. Germplasm collections made in 1986 in Guatemala, Argentina, Peru and Mexico as part of the CIAT-IBPGR collaborative effort.

Material	Country				
	Guatemala	Argentina	Peru	Mexico	Total
Cultivated species:					
P. vulgaris	9	95	143[a]		247
P. coccineus	34				34
P. polyantus	11				11
P. lunatus			46[a]		46
Wild species:					
P. anahuacensis				2	2
P. anisotrichus	8			10	18
P. augusti		4			4
P. coccineus	13			15	28
P. floribundus				2	2
P. glabellus				5	5
P. glaucocarpus				3	3
P. lunatus	2		4		6
P. macrolepis	1				1
P. neglectus				6	6
P. pachyrrhizoides			2		2
P. pedicellatus				11	11
P. pluriflorus				1	1
P. polyanthus	1				1
P. polymorphus				3	3
P. scabrellus				1	1
P. vulgaris	4	10	2	1	17
P. xanthotrichus	5			11[b]	16
P. sp. (gr. *pedicellatus*)				1	1
P. sp. (gr. *metcalfei*)				1	1
TOTAL	88	109	197	73	467

[a] Including 5 weedy types of each species.
[b] *P. xanthotrichus* v. *zimapanensis*

B. Data Management

The computer processing of the data generated by the Bean Program is not a novel concept - CIAT has been doing this for some twelve years. Data were collected by the scientists and either processed by the same scientist, or more commonly passed on to a biometrician for statistical analysis. When this work was completed, the data files were copied to tape and could be recalled if the workers involved in the original processing could recover the files and remember the necessary details of what was stored. In most cases other workers requiring the information for further computer processing or combination with other information would have to re-enter the summarized data from a printed document. When CIAT obtained a computer with sufficient capacity to handle all its scientific data a decision was made to use a database package to centrally organize the management of the Bean Program's data. Cullinet's IDMS was the system chosen for this purpose.

Progress in 1986

During the earlier part of the year, programs were written to manage the "experiments" part of the bean database. These components automate the display, update, and modification of data from any type of experiment both on-line and in batch. Data services are loading the data into the database.

The database was loaded with the common names of some fifty thousands accessions of the Genetic Resources Unit, and bred materials. Series S and G coded accessions were updated.

In mid-year the database group was reorganized to better share responsibilities, and the global scheme was redesigned to integrate the bean, cassava and agroecological databases. As a consequence of this, the programs were somewhat redesigned and recompiled to better access the data. On the basis of previously established standards of the sections, crosses made at CIAT and advanced lines were recoded. Disease resistance, color and growth habit data were added to the database. Bean accession data from the Genetic Resources Unit on brilliance, primary and secondary color, and shape and weight of the seed were added to the database. At the express request of the members of the Bean Program, time was also devoted to the preparation of a PL/I batch program to write a report combining basic information on the pedigree of crosses and advanced lines. This program runs outside IDMS but uses the information contained in the IDMS database. Until recently the production of field notebooks has been done either with SAS programs on the mainframe or with micros. Some basic dialogs were written to access data in the IDMS database to prepare field notebooks which will be used for the International Nurseries.

An attempt was made to load all of the data from the earlier years of the VEF trials, but many inconsistencies were revealed in the data, and they have been returned to the program scientists for revision.

As soon as this revision is complete the data will be loaded and the existing dialogs and programs will be available for consulting the information. In all, some 53 new dialogs were written to facilitate consultation of the bean database.

Priorities for the coming year

All of the VEF and IBYAN data will be loaded together with passport and other data provided by the Genetic Resources Unit.

The next IDMS/R release extends the use of ADS (Application Development System) to include batch processing of information in the database via the IDMS/R Central Version as opposed to the local model batch processing, previously available. Some processes will be rewritten to take advantage of this new facility. There should also be an opportunity to interface some of the bean network database to the relational part of IDMS/R so that Cullinet's microcomputer program, Golden Gate, can be used to transfer parts of the database to IBM PCs for local processing.

C. Genetic Variability from Biotechnological Techniques

During 1986, activities with *Phaseolus* in the Biotechnology Research Unit (BRU) focused on: a) developing tissue culture techniques for regeneration of bean plants using various organs and tissues and, b) developing electrophoretic techniques for genotype identification. Another activity of the BRU this year concentrated on monitoring research activities in aspects of bean biotechnology in other institutions, for the establishment of collaborative projects.

Bean tissue culture

In an earlier work, plant formation took place through proliferative "budding" when shoot-tip and nodal explants were cultured in a low salt medium with low auxin content (BRU Annual Report, 1985). As was later discovered, the axillary origin of plants restricts this technique to micropropagation. An efficient micropropagation technique, through multiple shoot formation, can be useful not only as a means to recover and multiply desirable F_1 or M_1 plants with problems of sexual reproduction, but also to develop *in vitro* selection techniques. Work on this subject will continue in the BRU in collaboration with Bean Program scientists.

Before developing a tissue culture cycle in beans it is necessary to overcome the problem of plant regeneration from the de-differentiated callus cultures. The bean genotype, type of explant, and composition of culture medium, are important factors to be considered. Callus induction using immature embryos has been successfully used for plant regeneration with other recalcitrant species.

This year, we observed the differentiation of somatic embryo-like structures on the surface of callus derived from immature embryos of a *P. vulgaris* x *P. lunatus* cross. Such structures had an anatomy reminiscent of somatic embryos (Figure 1). This morphogenic event occurred in a medium supplemented with glutamine and gibberellic acid.

An experiment was set up to find out whether the age (size) of the embryos and the composition of the culture medium would influence the induction of embryogenic callus in *P. vulgaris* and *P. lunatus*.

The size of the embryos used as explants had a marked effect on the frequency of embryogenic callus, being higher as the size of the explant increased (Table 1). Explant size overrided any detectable effect of medium composition when the embryos were larger than 2.5 mm. Only when the explants were 2.0-2.5 mm in size, did the medium containing both glutamine and GA act disadvantageously in both species. Smaller explants had a very low and non-consistent response in embryogenic callus formation, suggesting a need for culture medium improvement. *P. lunatus* showed higher frequency (40-60%) of embryogenic callus than *P. vulgaris* (25-30%), especially when large explants were used (Table 1). More work is needed to discover if the embryo-like structures can be taken to higher levels of differentiation.

Bean embryo rescue

Collaborative research is in progress with the GRU to use embryo rescue techniques in interspecific crosses of *P. vulgaris* with *P. acutifolius* and *P. lunatus*, as well as in crosses of wild with aborigineus *P. vulgaris*.

The first phase of the project concentrated on characterization of selected genotypes using morphological descriptors. Subsequently, symptoms conducive to abortion were established for the crosses: *P. vulgaris* x *P. acutifolius* and reciprocal, and *P. vulgaris* x *P. lunatus* and reciprocal. Abortion was associated to reduction of pod length and width, pod yellowing, and loss of pod turgidity. Besides pods, abortion also occurred at flower and flower bud stages, with flower bud abortion being the most common for all crosses. In the cross *P. lunatus* x *P. vulgaris*, flower bud and flower abortion reached 92%, with the remaining 8% corresponding to pod abortion (initiated pods which then suffered early abscision). The high incidence of flower bud abortion has made it difficult to carry out intense embryo rescue work. However, embryos were rescued after eight days from pollination of *P. vulgaris* x *P. lunatus*; then cultured out, resulting in a few F_1 plants. Seed of these plants was obtained for analysis of the F_2 generation. Research is underway to refine pollination techniques, and reduce flower bud abortion.

The possibility of performing pollination *in vitro* should be explored and implemented, in future work.

In vitro embryo germination has also been used to recover plants from wild bean crosses with serious germination problems and scarce seed availability in the GRU. This technique was recently applied to the following crosses:

Crosses		No. plants recovered
1. *P. vulgaris* wild type x	*P. vulgaris* var. *aborigineus*	1
S0478	DGD-629	
Costa Rica	Argentina	
2. *P. vulgaris* var. *aborigineus* x	*P. vulgaris* wild type	3
DGD-629	DGD-1610	
Argentina	Guatemala	
3. *P. vulgaris* var. *aborigineus* x	*P. vulgaris* wild type	1
DGD-1711	DGD-1961	
Argentina	Peru	

Genotype identification by electrophoresis

Following one and a half years of activities at the University of Manitoba, the IDRC-funded collaborative project on electrophoresis moved to CIAT this year, to further develop electrophoretic methodologies and procedures with beans.

Two methodologies based on the acid soluble seed proteins and SDS soluble residual proteins were developed at the University of Manitoba.

At CIAT, the acid soluble seed proteins (acid PAGE) procedure has been applied to about 24 groups of *P. vulgaris* which are highly similar in their morphology. We have learned that much chemical heterogenity exists within a single morphologically identical group; for example, in morphology group 4, all three accessions (G 09207, G 11127 and G 11890) were different according to their electrophoretic patterns; similarly in morphology group 7, all the accessions (G 1015, G 11141, G 11159, G 11213, G 11260, G 13193 and G 15781) showed chemical variation in their acid soluble storage proteins while they were morphologically similar. Group 10 is represented by accessions of "Flor de Mayo" both originated and processed in Mexico with accessions G Nos. 5897, 10944, 10945, 11015, 13624, 13625, 13638, 13640 and 13645. Out of this group, accession 13624 was very different with regard to the protein pattern; accessions 13625 and 13640 also showed different patterns; the rest of the accessions were similar (Figure 2).

Groups 18 (Kaboon), 22 (Canario Divex), 23 (Great Northern) and 24 (10233-M-M-M-1IPM-11-1-M) each having two morphologically identical accessions, were found to be similar in regard to their electrophoretic patterns; however in groups 19 (Vermelho), 20 (Constanza) and 21 (Pompadour) each accession showed a different pattern.

Electrophoresis of the variety "Chimbolito" and its irradiated mutant "Uneca" from Costa Rica, showed the presence of extra bands in the irradiated mutant.

This methodology (acid PAGE) is being tested with more accessions and other problem material to assess chemical variability. Also, several samples have been tested to determine the type of phaseolin genotype (S,T or C). The technique could also be applied to establish correlations between germplasm collections and their centers of origin.

Collaborative research

As stated above, the BRU works closely with Bean Program scientists, in pinpointing areas of research with potential high payoff in terms of technology development, to be undertaken in the form of collaborative projects. At this stage two critical areas of research have been identified for collaborative projects: a) development of a tissue culture cycle in *Phaseolus*, which will allow regeneration of plants from non-organized cell tissue cultures. Application for funding has been submitted to the Italian government, and the project is slated to begin in 1987; b) development of molecular markers in *P. vulgaris* using DNA restriction fragment length polymorphisms (RFLPs). This project was submitted and recently approved by AID's scientific peer reviewers; if funds are allocated it should start in the last quarter of 1987. Some research has already been initiated at the University of Florida, Gainesville, by Dr. E. Vallejos. The identification and locating of a large number of molecular markers, distributed throughout the bean genome, will permit the tagging of genes of economic importance. RFLPs could be used to map qualitative and quantitative traits by linkage analysis and expedite the recovery of recurrent parent alleles, and thus reduce the length of breeding programs.

Table 1. Effect of culture medium and size of explant (immature embryos) on frequency of embryogenic callus formation in *P. vulgaris* and *P. lunatus*.

Culture Medium*	Embryo (explant) length in mm.			
	0.5	1.0-1.5	2.0-2.5	2.5
	Frequency of embryogenic callus			
P. vulgaris (G04090)				
A	0/8	2/26	2/12	4/12
B	1/2	2/46	3/15	4/16
C	0/1	5/29	8/30	3/13
D	0/5	2/22	1/13	1/4
P. lunatus (G25137)				
A	-	0/9	4/9	14/22
B	-	8/25	17/38	18/40
C	-	0/1	5/14	19/16
D	-	0/3	0/2	19/43

*MS (3% sucrose + 100 mg/l inositol + 1 mg/l thiamine + 5mg/l nicotinic acid + 0.5 mg/l pyridoxine) + glutamine and GA (mg/l):0 and 0 (A); 50 and 0 (B); 0 and 0.035 (C); 50 and 0.035 (D).

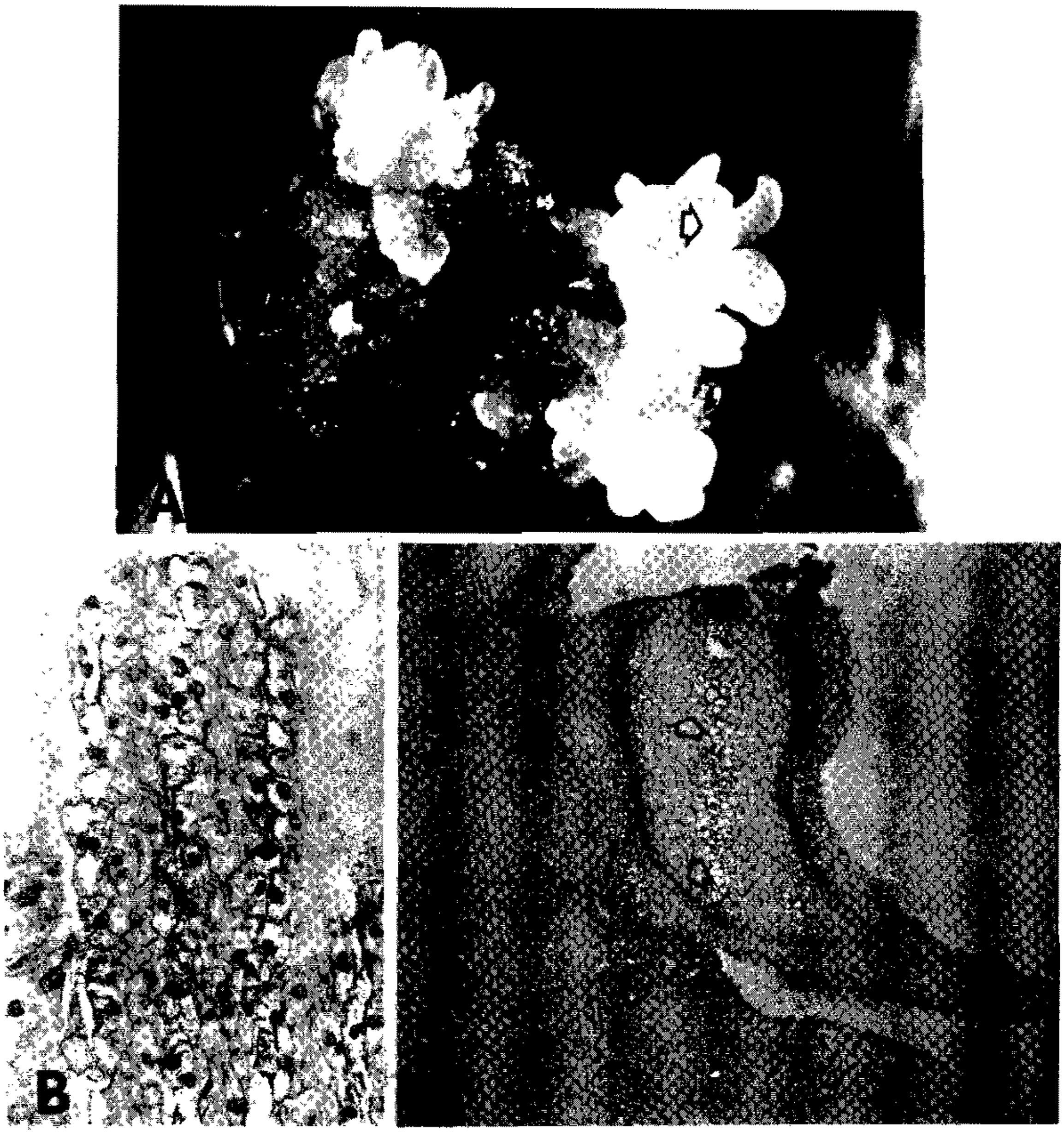


Figure 2-1. Induction of somatic embryo like structures on callus derived from immature sexual embryo of Phaseolus.

A. Somatic embryo like structures, globular and heart shaped (arrows) differentiated on callus.

B. Longitudinal section of an embryo-like structure (heart shaped) differentiated on "maternal" callus tissue.

C. Longitudinal section of an embryo-like structure showing polarity, provascular strands and sub-apical rib meristem (arrows).

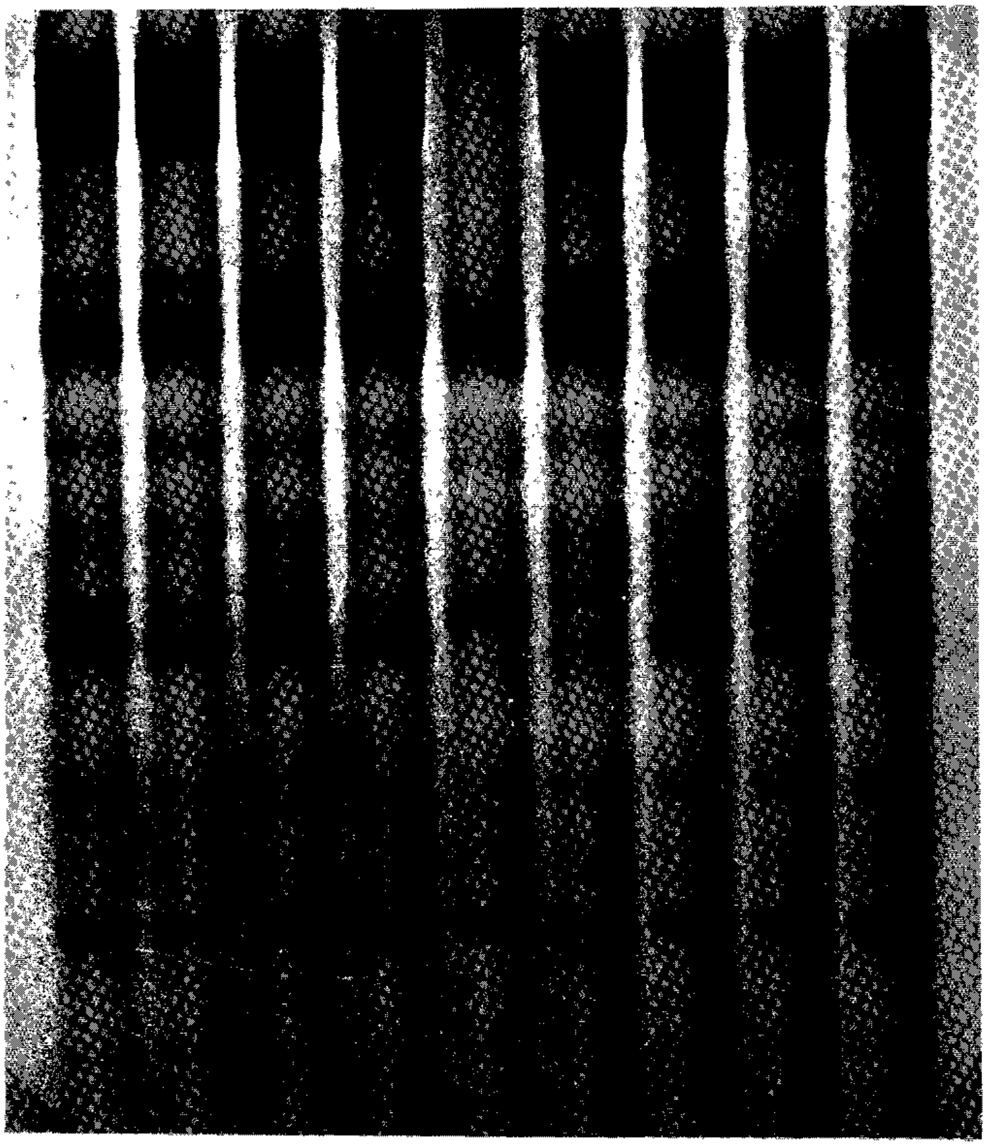


Figure 2-2. Acid PAGE patterns of seed storage proteins of morphologically similar group ("Flor de Mayo") from Mexicc <u>P.vulgaris</u>. Nine slots from left to right contain CIAT accessions G Nos.5897, 10944, 10945, 11015, 13624, 13625, 13638, 13640 and 13645.
Note that accession G13624 shows different pattern; accessions G 13625 and 13640 show little differences; the rest of the accessions are electrophoretically similar.

D. Variability from Interspecific Hybridization

The main objective of the CIAT-Gembloux project is the genetic improvement of P. vulgaris through interspecific hybridization. The major donor parent, P. coccineus, is a species which shows many useful characteristics not expressed or poorly expressed in the common bean gene pool. Therefore a breeding program with P. vulgaris requires as a prerequisite the seed multiplication and complete evaluation of the P. coccineus collection held by CIAT.

Progress made in 1986 includes:

- The implementation of an international yield trial for P. coccineus to assess the value of this crop, and make new germplasm available for direct use.

- The identification of new sources of resistance to Ascochyta leaf spot for which a severe selection pressure exists in Colombia; to bean fly for which a research collaboration has been set up both in A.V.R.D.C, Taiwan, and East Africa; and to bean common mosaic virus.

- The development of new interspecific lines to be incorporated in a next VEF trial.

P. coccineus multiplication and evaluation

The seed increase of P. coccineus continued in 1986 according to the methodology described in previous reports, to avoid mixing up and to preserve genetic integrity of each population. Multiplication is carried out in meshcages at Popayan and in open field at Rio Negro with racemes protected by paper bags. The building of a new screenhouse at Popayan has facilitated seed increase.

In 1986, 120 accessions of P. coccineus were planted in Rio Negro to obtain open pollinated seed for further evaluation and distribution. Seeds from controlled pollination are obtained by hand pollination between plants of the same accession or by selfing, and are used to maintain the accession.

Preliminary evaluations are made during seed multiplication on morphological characteristics: germination, stem pigmentation, growth habit, flower color, stigma shape, bracteole length and shape.

P. coccineus evaluation for Ascochyta resistance at Rio Negro

Some 33 accessions of the subspecies polyanthus and 16 accessions of the subspecies coccineus were evaluated in Rio Negro during the second semester of 1985 for their reaction to Ascochyta and other fungal diseases. The accessions were planted in a double replicated trial in relay with maize, using the P. vulgaris cultivar E 1056 as susceptible check and G 6040 as tolerant one. The P. coccineus subsp. polyanthus Guate 1076, from Guatemala, was planted as the resistant check.

To obtain adequate selection pressure of Ascochyta sp., artificial inoculation was done. Reaction to diseases were visually observed at flowering, and at the beginning and end of maturity. The results show that the subspecies polyanthus has a very good resistance reaction to the diseases, presenting no lesion or with lesions limited to the primary leaves. On the other hand, different reactions were observed among the various populations of the subspecies coccineus. Some of them were resistant with lesions limited to the primary leaves and others were highly susceptible. The best accessions were three populations from Colombia (G 35357, G 35358 and G 35361) and three populations from Mexico (G 35421, G 35429 and G 35430).

The reactions to anthracnose, angular leaf spot, rust and powdery mildew were also observed. Results are summarized in Table 1. More information on these diseases is provided in the chapters on disease under Genetic Improvement and Related Activities.

The productivity of P. coccineus subsp. polyanthus was high, with a yield of 3717 to 5726 kg/ha and a mean of 4722 kg/ha. P. coccineus subs. coccineus did not produce very well, probably because of its greater vegetative vigor.

P. coccineus resistance to bean fly (Ophiomyia phaseoli)

In 1985, 202 introductions of subspecies coccineus and polyanthus were sent to Dr. Talekar at A.V.R.D.C. (Taiwan) to be studied for their reaction to bean fly, a very important insect pest of bean in parts of Asia and Africa. The best resistant populations will be used in crosses with the common bean.

The initial source of resistance came from a Mexican P. coccineus accession, G 35023, but during 1983, evaluations identified populations more resistant than G 35023, which were confirmed by the evaluations made in 1985. The best resistance sources identified up to now come from two accessions of the subspecies coccineus (G 35194 and G 35220) and from six populations of the polyanthus subspecies (G 35345, G 35350, G 35432, G 35505, G 35526 and 35547).

More information on bean fly research can be found in the chapter titled Resistance to Invertebrate Pests.

Other evaluations

A group of 305 accessions of both coccineus and polyanthus subspecies were evaluated by the bean virologist to test for resistance to bean common mosaic virus. No reaction at all was observed through the whole group, so some of these accessions are being retested for BCMV resistance and also for resistance to BGMV.

Forty-five populations of both subspecies harvested at Rio Negro in 1985 were analyzed for cooking time, using the Mattson's cooker. Five samples were cooked from each accession and the mean cooking time ranged from 25 to 60 minutes. The vulgaris check cooked in 20 minutes.

IBYAN (International Bean Yield and Adaptation Nursery) for *P. coccineus*

The main objective of the nursery is to promote the production of *P. coccineus* subsp. *polyanthus* and of *P. coccineus* subsp. *coccineus*.

Secondary objectives of the nursery are to evaluate under various environmental conditions the yield and adaptation of promising accessions of *P. coccineus* subsp. *polyanthus*, to compare the accessions with the best local varieties (climbing *P. vulgaris* and *P. coccineus*), and to show the value of using the species directly and not only as a source of interesting characteristics for the improvement of the common bean by interspecific hybridization.

P. coccineus subsp. *polyanthus* is a climbing bean cultivated from Mexico to northern Peru, in altitudes ranging from 1600 to 2600 m. It matures later than the common bean, but is able to grow again after cutting. Its pluriannual character can be an advantage by its permanent occupation of the land and continuous production after cutting. Its seed is bigger and needs a longer cooking time than the common bean. Nevertheless, the species is interesting for its adaptation to high altitude and more humid regions, especially because of disease and pest resistance (e.g. to *Ascochyta*) and potential productivity.

The trial includes 12 entries: ten *P. coccineus* subsp. *polyanthus* accessions selected during the second semester of 1985 in Rio Negro for disease resistance and productivity; and two local varieties planted as checks (*P. vulgaris* and/or *P. coccineus*, according to the region) with three replications in a randomized design.

The trial was also planted in Popayan, in Rio Negro and Pasto. In Popayan, no disease was observed except for powdery mildew and production was low because of the dry weather. Trials have been sent to Guatemala, Peru, Ecuador, Ethiopia and Rwanda in order to compare *P. coccineus* subsp. *polyanthus* adaptation in different ecologies. The results will be sent to CIAT by the collaborators.

Interspecific hybridization

The *P. vulgaris* x *P. coccineus* populations include many highly allogamous materials, due to the floral biology of the scarlet runner bean, and segregation continues in advanced generations.

The breeding scheme adopted is a method of cumulative selection which involves reselection generation after generation and interbreeding of selected plants. The breeding methodology includes the following steps: selection of the best individual plants for yield and disease resistance, and the favoring of interbreeding of the advanced lines. The ultimate goal is to provide advanced lines to the bean breeders for the VEF.

Results of the *P. vulgaris* x *P. coccineus* trials

PALMIRA

During 1986, F_7 and F_8 interspecific hybrids between *P. vulgaris* and *P. coccineus* selected in Taiwan for resistance to bean fly were planted in Palmira for multiplication, agronomic evaluation and backcrossing with *P. vulgaris* elite. A total of 213 out of 2304 plants was selected and the seed was sent to Taiwan. Seed from 25 backcrosses made with six *P. vulgaris* elite varieties was also sent.

RIO NEGRO 1985 B

In Rio Negro, 143 F_5 to F_8 populations of interspecific direct hybrids (*P. vulgaris* x *P. coccineus* subsp. *coccineus* or subsp. *polyanthus*) were planted for *Ascochyta* resistance evaluation. Artificial inoculation was made one month after planting to insure an adequate selection pressure. Architecture and adaptation of the plants were also observed and 74 plants from 54 different populations were selected. The disease reactions of the best plants are presented in Table 2. Seeds of those hybrids were given to the breeding program to be integrated in their selection and crossing program. Part of the harvested seeds were planted in Popayan (1986 A) and part in Rio Negro (1986 B) where the selection for disease resistance was continued.

POPAYAN 1985 B

In Popayan, the plantings in the second semester of 1985 concerned F_1 to F_5 direct and complex hybrid populations as well as some hybrids from backcrosses and the constitution of a crossing block.

The F_1 populations were made up of 13 direct hybrids of *P. vulgaris* x *P. coccineus* subsp. *coccineus* (made to introduce resistance to BGMV into *P. vulgaris*), 18 *P. vulgaris* x *P. coccineus* subsp. *polyanthus* and 13 complex hybrids populations (for *Ascochyta*), and 7 *P. vulgaris* x *P. coccineus* subsp. *coccineus* and 9 complex hybrids (for bean fly resistance). The direct hybrid plants were selfed to multiply the seeds.

In advanced progenies, individual selection was made for disease resistance (mainly *Ascochyta*), and for other characters like architecture adaptation. The seeds harvested on the selected plants were planted in 1986 A for the next cycle of selection. The best hybrids of the F_4 and F_5 progenies are listed in Table 3.

POPAYAN 1986 A

During the first semester of 1986, the weather was dry and no *Ascochyta* was observed in the field. However, in the advanced progenies F_6, F_7 and F_8 coming from selections from Rio Negro 1985 B, individual plants were selected for architecture and production. Table 4 gives the best hybrid combinations which have been planted in Popayan in the second semester of 1986.

As in 1985 B, some 57 F_1 hybrid populations made for *Ascochyta* resistance, 31 populations for bean fly resistance and four populations for architectural traits, were multiplied to obtain enough seed for further selection.

The F_2 nursery was composed of two *P. vulgaris* x *P. coccineus* subsp. *polyanthus* populations, and seven complex hybrid populations (one [PC F x PV] x PC_p and six [(PC_W x PV)] x PC_p populations), planted for *Ascochyta* resistance. All the plants were harvested and the F_3 seeds planted for evaluation during 1986 B at Popayan.

VEF 1986

Five advanced lines of the direct *P. vulgaris* x *P. coccineus* subsp. *coccineus* cross were included in the VEF this year. All of them are indeterminate climbing types and came from an adaptation trial in Palmira during 1985. They include two ICTA-Quetzal x M 7285 lines (black and brown seeds), two Aete 1/38 x M 7688A lines (Red and Cream), and one Cena 164 x M 7689A line (Cream).

Future activities of the project

In addition to the on-going activities, 103 *P. coccineus* accessions were given to the bean breeding program to be evaluated for *Mustia* and common bacterial blight resistance. The evaluation of the *P. coccineus* germplasm for BCMV and BGMV begun in 1986 will continue in 1987. Interspecific hybrid lines will be sent to Guatemala, to be evaluated for resistance to the bean weevil, *Apion godmani*.

Table 1. Reaction of 16 P. coccineus subsp. coccineus subsp. and 33 P. coccineus subsp. P. polyanthus introductions to some foliar diseases.

Disease	P. coccineus subsp. coccineus: # of introductions showing few symptoms	P. coccineus subsp. coccineus: # of introductions susceptible	P. coccineus subsp. polyanthus: # of introductions showing few symptoms	P. coccineus subsp. polyanthus: # of introductions susceptible
Anthracnose	16	0	33	0
Angular leaf spot	16	0	30	3
Rust	15	1	30	3
Powdery mildew	10	6	31	2

Table 2. Reaction of the best plants selected in Rio Negro 1985 B to disease.

Cross[1]	Identification	Progeny	Reaction to[2]					Days to flowering
			Asc	Rust	Ant	ALS	PM	
PVxPC_p	Mortiño x X_7	F_6	1	2	2	2	1	58
	Ecuador 299 x Piloy	F_5	2	2	1	1	2	61
	Guate 1008 x Piloy	F_7	1	2	2	2	1	68
PV x PC_c	NI 141 x G 35174	F_7	1	2	2	2	1	65
	NI 141 x G 35174	F_7	1	2	2	2	1	61
	Guate 467 x Guate 1259	F_5	2	2	2	2	1	66
	Pasto x Guate 1259	F_5	2	2	2	2	2	71
	Pasto x Guate 1259	F_5	2	2	2	2	2	68
Checks	E 1056		8	5	5	4	5	63
	G 6040		5	3	2	3	7	71

1. PV = *P. vulgaris*; PC_p = *P. coccineus* subsp. *polyanthus*; PC_c = *P. coccineus* subsp. *coccineus*
2. Asc = *Ascochyta*; Ant= Anthracnose; ALS = Angular leaf spot; PM = Powdery Mildew; Evaluation based on a 1=9 scale of intensity

Table 3. Best selections for <u>Ascochyta</u> resistance in the advanced progenies at Popayan 1985 B.

Cross[1]	Identification	Progeny	Days to Flowering	Reaction (1-9 scale)	Characteristics
PV x PC_c	Cargamanto x 88-1	F_5	56	2	long racemes
	Cargamanto x 88-1	F_5	50	2	long racemes
$(PC_w xPV)xPC_c$	(NI889xBAT1274)xDGD78/045	F_4	49	2	long racemes, productivity
	(NI889xBAT1274)xDGD78/045	F_4	50	2	terminal stigma, productivity
	(NI889xBAT1274)xDGD78/045	F_4	54	2	productivity
	(NI889xBAT1274)xDGD78/045	F_4	67	2	long racemes
	(NI889xBAT1274)xDGD78/045	F_4	48	2	good disease resistance
	(NI889 x D145) x NI 15	F_4	65	2	
	(NI889 x D145) x NI 15	F_4	55	2	extrorse stigma long racemes, productivity
$[(PC_w xPV)xPV]xPC_c$	[(NI889xG3807)xA133]xG35145	F_4	59	2	growth habit
Check	E 1056			8	

Table 4. Best F_7, F_8 and F_9 interspecific *P. vulgaris* x *P. coccineus* hybrids selected for adaptation at Popayan 1986 A.

Progeny	Identification	Cross[1]	Number of populations
F_7	Ecuador 299 x Piloy	PV x PC_p	8
	Guate 467 x Guate 1259	PV x PC_c	9
	Pasto x Guate 1259	PV x PC_c	2
F_8	Mortiño x X_7	PV x PC_p	17
	Guate 1008 x Piloy	PV x PC_p	11
F_9	NI 141 x G 35174	PV x PC_c	5

1. PV = *P. vulgaris*; PC_c = *P. coccineus* subsp. *coccineus*; PC_p = *P. coccineus* subsp *polyanthus*;
PC_w = *P. coccineus* wild forms.

II. GENETIC IMPROVEMENT AND RELATED ACTIVITIES

A Introduction

Germplasm improvement activities of the Bean Program are based upon the large variability in the germplasm collection stored at CIAT. In the evaluation of the germplasm bank useful traits are identified as having the potential to solve or reduce the effect of production-limiting factors. However, in many instances the level of expression of desirable traits in germplasm bank accessions is insufficient to solve particular production constraints (e.g.the level of resistance to BCMV, Ascochyta leaf spot, drought tolerance, resistance to storage insects, and ability to fix atmospheric nitrogen). Also, such variability often occurs in unadapted material, or in undesirable colors. For the improvement of commercial varieties, combinations of desirable characters based on production problems and consumer requirements for each ecological zone are needed. Therefore genetic improvement activities of the Bean Program can be divided into two aspects: a) character improvement - the development of maximal expression of a character in a diversity of genotypes by accumulation of different genes for resistance mechanisms or other desirable characteristics; and, b) character deployment or varietal improvement - the recombination or use of these characters in commercial cultivars according to the needs of the particular production region for which the material is intended. In the latter activity, local commercial cultivars are used heavily in crossing to assure appropriate adaptation in progenies.

Table 1 lists the specific responsibilities of the three breeding groups in the Bean Program in these two activities, with the number of crosses made during 1986, and the number of coded lines developed and submitted to the VEF in 1986.

Section D of this annual report, REGIONAL ACTIVITIES, summarizes character deployment or varietal improvement activities carried out in the specific production regions. The section following this introduction reports on the genetic improvement activities carried out at CIAT headquarters to back up regional activities, as well as on various activities in genetic improvement done within regional projects or production regions.

Table 1. Specific responsibilities, number of crosses made, and lines coded by the three breeders in the CIAT Bean Program for character improvement and deployment projects in 1986.

Research area	Responsible breeding program	No. of crosses	No. of coded lines submitted to VEF 86	No. of populations shipped
Character improvement				
Bean common mosaic virus	III	159	10	175
Bean golden mosaic virus	I	128	7	
Rust	I	10		
Common bacterial blight	I	115	54	
Halo blight	III	34	4	
Web blight	I		37	58
Anthracnose	II	14		
Angular leaf spot	II	3		
Ascochyta	III	138	23	54
Bean scab	III			
Empoasca leafhoppers	III	122	27	
Apion pod weevil	I	4		
Storage insects	III	23	16	
Bean fly	III	13		
Nematodes	III	20		
Drought	II	19		
Temperature/photoperiod	III	28		
Low P	II	40		11
Maturity	II	152		
N_2 fixation	I	13		
Architecture	II			
Yield potential	II	211		
Snap beans	III	90		
Character deployment				
Africa	III	314	87	644
Central America	I	256	130	43
Caribbean	I	28	32	17
Coastal Mexico, Peru	I	119	20	83
Brazil black beans	I	132		
Brazil (non-black)	II	105	343	197
Mexican highlands	II	229	196	90
Argentina (black)	I	12		12
Argentina/W. Asia	II	169		55
Andean Zone	III	319	536	288
Peru/Chile	I		162	
TOTAL		3019	1684	1727

B. Improvement of Individual Characters

1. Resistance to Fungal and Bacterial Diseases

Introduction

Bean pathogens are important constraints to production in most bean growing regions of the world. The principal strategy used by the Bean Program to manage the majority of these pathogens is disease resistance. For some diseases, studies are also conducted on the influence of cropping system and agronomic practices on the initiation of infection, disease progress, and final disease severity. The main bacterial and fungal diseases studied by the Bean Program are anthracnose, rust, common bacterial blight, angular leaf spot, root rots, halo blight, and Ascochyta blight. Research conducted during 1986 concentrated on rust, angular leaf spot, anthracnose, common bacterial blight and halo blight as well as on developing methodologies to better determine disease resistance mechanisms.

Principle activities this year comprised the evaluation of several advanced and segregating bean nurseries for their reactions under field conditions to the major bean pathogens. The results of these evaluations are summarized in Section C of this report, Evaluation of Uniform Nurseries. While the majority of field evaluations were conducted whithin Colombia, many nurseries were evaluated under local conditions by scientists from national programs.

Studies crucial to the development of an appropriate breeding strategy were conducted this year on the existing pathogenic variation of many bean pathogens known to possess races. Research into disease resistance mechanisms that may exist in the bean accessions presently available was also conducted, with the objective of learning more about the possible types of resistance that can be utilized in breeding beans for disease resistance.

RUST

This disease, caused by the highly variable pathogen *Uromyces appendiculatus* var. *appendiculatus* (= *U. phaseoli*) is of economic importance in many areas of Latin America and Africa. The most resistant entries evaluated in the International Bean Rust Nursery (IBRN) in many locations of the world, are shown in Table 1. All of the cultivars evaluated are susceptible in at least one location suggesting broad variability for the rust pathogen. The cultivars Redlands Pioneer, Redlands Greenleaf B, and Redlands Greenleaf C were susceptible at the least number of locations.

During 1986, several bean nurseries were evaluated under field conditions for their reaction to the rust pathogen. The majority of rust resistant and intermediate entries from the VEF 1985 were reevaluated in 1986. Of 201 entries, 88 (43.78%) were resistant, 106 (52.74%) were intermediate and only six (3.48%) were susceptible. Similarly, 83 entries from the 1985 EP were evaluated and 53 (63.8%) were resistant, 22 (26.6%) intermediate and eight (9.6%) were susceptible. In all cases the resistant check, BAT 308, had an average reaction of 3, in a scale of 1 to 9, and the susceptible check BAT 83, had a susceptible reaction that fluctuated between 7 and 8. The most promising lines will be evaluated elsewhere.

From rust evaluations conducted in Cuba during a severe rust epidemic occurring in 1985, 55 bean lines were selected for their rust resistance and evaluated under field conditions in Palmira. Of these, only three lines had a resistant reaction, 27 an intermediate and 25 a susceptible reaction. These results suggest that the isolates of the rust pathogen from Cuba are different from those found in Palmira and that the pathogenic variation in Cuba is less extensive than that found in Palmira. Therefore, lines that are rust resistant or having intermediate reactions in both locations, are most easily selected from evaluations conducted in Palmira.

Similar evaluations were conducted for 55 bean lines with commercial grain color for the Mexican highlands which had been evaluated as having resistant or intermediate rust reaction in Texcoco, Mexico. Some of these lines were evaluated twice in Mexico before they were evaluated in Colombia. Again some lines resistant in one location were susceptible in the other (such as A 293 and MAN 11), but several lines were evaluated as resistant in both locations in more than one year (Table 2). Those rust resistant lines at both locations are utilized as sources of rust resistance for the Mexican highlands.

ANGULAR LEAF SPOT

In the search for bean lines with broad resistance to the ALS pathogen, 422 bean lines from advanced CIAT bean nurseries previously evaluated as ALS resistant or intermediate in Popayan, were also evaluated in Santander de Quilichao, Colombia. From previous work conducted in the field and greenhouse, it is known that the isolates of the ALS pathogen from Quilichao are different from those found in Popayan (see Bean Program Annual Report 1985). From these, 77 lines were selected for their intermediate or resistant ALS reaction in Quilichao. These (along with 1066 bean lines previously selected in Quilichao for their ALS reaction), were planted during both seasons of 1986. The materials were interspersed among susceptible disease spreaders planted in advance. Bean lines known to be good disease checks were distributed throughout the field. 249 entries were selected from the first planting of 1986. In the second semester, 4 row plots, each 4 meters long were utilized with the objective of evaluating their ALS reaction, adaptation and reaction to other diseases. Several evaluations of the foliage and pods were conducted during the semester.

None of the lines evaluated had an immune reaction, but several had either a resistant or intermediate reaction under a very adequate disease pressure corroborated by the severe ALS attack observed on the susceptible checks (Table 3). Characteristically, these lines generally have a low number of small lesions, and they do not senesce or defoliate prematurely as do susceptible lines, where senescence is caused by large lesions that coalesce both on the foliage and on the pods. Many of the lines which have been evaluated as intermediate or resistant in Colombia have commercial grain color. These will be included in the International Bean Angular Leaf Spot Resistant Nursery (BALSIT). The BALSIT is distributed for evaluation to several areas of the world where ALS is a major problem. Those bean lines shown to have very broad ALS resistance are subsequently used as sources of resistance in the breeding program.

ANTHRACNOSE

Bean anthracnose is one of the most important diseases of beans in Latin America and Africa. The causal agent, Colletotrichum lindemuthianum, is seed-borne and has extensive pathogenic variation, explaining why many bean varieties exhibit a differential reaction across locations.

Despite the importance of anthracnose in many large bean producing areas of these two continents, little was known about the extent of the pathogenic variation of C. lindemuthianum as the reaction and value of many anthracnose resistant varieties in these regions were unknown. During the past few years, (see CIAT Bean Program Annual Reports, 1981, 1982, 1983 and 1984), the emphasis of the anthracnose research conducted at CIAT has included the identification of new and broad anthracnose resistant sources; the study of the existing pathogenic variation of C. lindemuthianum where anthracnose is an important problem; and, local evaluation under field and greenhouse conditions of the most promising bean resistant sources and lines and varieties with commercial grain color and good local adaptation. Much of this pathology work, particularly that related to the evaluations of bean germplasm, was conducted in collaboration with the breeding sections of the bean program at CIAT.

During 1986, and in close collaboration with bean scientists from the national research programs, studies were conducted on the pathogenic variation and reaction of the anthracnose resistant sources to isolates of C. lindemuthianum from Costa Rica, Colombia, and various African countries.

Six isolates of C. lindemuthianum (from Kenya, Zaire, Tanzania and Burundi), were inoculated on a set of 13 bean anthracnose differential varieties (Table 4). The isolates were characterized according to the reactions they elicited on the differential varieties, into three distinct pathogenicity groups. Three isolates: Cl-1 AFR, CL-3 AFR and CL-5 AFR (from Kenya, Tanzania and Zaire, respectively), elicited almost identical reaction on the differential varieties, and, according to the reaction of the first four varieties (Michelite, Michigan Dark Red Kidney, Perry Marrow and Cornell 49242) they belong to the beta race group. Two isolates, CL-2 AFR and CL-4 AFR from Zaire and Burundi, respectively, belong to the Brazil I race group and one isolate from Kenya, CL-6 AF, to the Mexico II race group. It is worth noting that none of the African isolates characterized, attacked the Cornell 49242 source of the ARE anthracnose resistance gene.

Bean lines and varieties utilized as parents for breeding anthracnose resistance for Africa were also inoculated with the same isolates (Table 5). The Mexican bean germplasm accession G 2333 had a resistant reaction to all the African isolates. This accession also has a resistant reaction to a very wide range of isolates from other areas of the world. Similarly, BAT 1386, as well as AB 136, A 475 and G 2338 utilized as differential varieties, had a resistant reaction to all African isolates studied. Three of the African cultivars inoculated, Habyalimana, Cyanuyu and C 10 (all from Rwanda) also had resistant reactions to all isolates. Urobonobono, a cultivar from Burundi which has a susceptible anthracnose reaction under field conditions in that country, was also susceptible to the C. lindemuthianum isolate from Burundi, as well as to isolates of the race group Brazil I from Zaire and Kenya, but it had a resistant reaction to all of the other isolates. Similarly, cultivars Mutiki 2 from Uganda, and Kibungo 2 from Rwanda, were susceptible to all of the isolates except to those belonging to râce group Brazil I. These results clearly suggest that it will be possible to combine anthracnose resistance genes by crossing different cultivars with race specific resistance. This gene pyramiding strategy will be combined with the use of widely resistant sources in order to broaden and to diversify the genetic base of the anthracnose resistance for Africa.

Hybrid populations in F_2 were also screened against selected isolates, according to the resistance found in the parents, as described above. In Figure 1, the segregation of F_2 plants, in four crosses of BAT 1386 with susceptible African cultivars, follows a bimodal distribution. This suggests that a single dominant gene controls resistance in BAT 1386 to the race group beta isolates, and there is evidence in the same figure for some quantitative effects as well. In similar crosses using A 240 as the resistance source, the same type of segregation occurred, suggesting the presence of the same dominant gene. Resistant single plants have been backcrossed onto the African cultivars, and this procedure will be continued for a second generation in order to incorporate the gene for resistance into these important cultivars. In crosses of resistant by resistant parents there was evidence (from the lack of susceptible segregants) that the following parents have the same gene for resistance: A 30, A 252, PVMX 1535, Urubonobono and Carolina. In crosses with the African sources showing resistance to all isolates, (Cyunyu, Habyalimana and C 10), the segregation suggested that more than one gene was controlling the resistance in these cultivars.

In crosses screened with isolates belonging to the race group Brazil 1, an almost perfect segregation for a single dominant gene for resistance was obtained in crosses using A 483 and A 484 as the resistance source (Figure 2). As before, the crosses with Cyunyu and C 10 showed a more quantitative distribution, suggesting that these cultivars may have a quantitatively inherited race-non-specific resistance (Figure 3).

Anthracnose has been reported for years from Costa Rica, but rarely has the disease caused severe damage. However, with the introduction of new varieties, some of which are anthracnose susceptible, the disease has become a production problem in certain areas. Therefore, a study was conducted in collaboration with a scientist from the University of Costa Rica to determine the pathogenic variation among populations of C. lindemuthianum in that country and to evaluate the reaction of several anthracnose resistance sources and new varieties with commercial grain color for Costa Rica.

Six isolates, three from the central region, and three from the northern region of Costa Rica, were inoculated on twelve bean anthracnose differential varieties. An isolate of the race kappa from Europe was used for comparison. Based on the reaction of the differential varieties, two isolates from the central region (one from Alajuela and the other from Grecia), belong to the same race. The other isolate from this region, Quepos, was different. All three isolates from the northern region elicited identical reaction on the six first differential varieties but not on the rest (Table 6). Based on the reaction of the first four differential varieties (Michilite, MDRK, Perry Marrow and Cornell 49242), the Alajuela and Grecia isolates from the central region, belong to the race group Brazil I, similar to that for the African isolates CL-2 from Zaire and CL-4 from Burundi (see Tables 4 and 5). However, while the African isolates did not attack Cornell 49242, the source of the ARE gene of anthracnose resistance, two isolates from Costa Rica attacked Cornell 49242 severely. The other isolate from the central region, originating from Grecia, was identical to the European kappa race and both did attack Cornell 49242, based also on the reaction of the first four differentials. The three isolates from the northern region belong to the same race group, denominated Alpha Brazil, which also attacks Cornell 49242. However, two of these isolates attacked the differential variety and resistance source To and one isolate attacked Tu.

Based on the characterization of the Costa Rican isolates, 56 bean lines and varieties (some with commercial grain color for Costa

Rica and others used as sources of anthracnose resistance), were also evaluated for their reaction to the existing pathogenic variation found. One isolate representative of each race group was utilized : Alajuela for race group Brazil I, Quepos for kappa and Esparza for Alpha Brazil. Most of the commercial varieties were susceptible to one or more races of the pathogen (Table 7), but many of the sources of anthracnose resistance used were resistant to all the pathogenic races found in this study. Therefore, it is possible to select anthracnose resistance sources from a wide variety of accessions having different grain colors that have already been crossed with varieties having commercial grain color for Costa Rica.

Disease resistance mechanisms

From multiple evaluations conducted both under field and greenhouse conditions it is evident that different bean varieties have different disease reaction mechanisms to their pathogens. The understanding of these mechanisms is very important for developing a sound breeding strategy for disease resistance.

Last year, (see Bean Program Annual Report, 1985) we reported on disease reaction mechanisms available in the bean varieties to different isolates of *Isariopsis griseola* of the angular leaf spot pathogen. This year we report on some disease reactions mechanisms studied for anthracnose and rust.

ANTHRACNOSE

Some bean lines inoculated under greenhouse conditions with isolates of *Colletotrichum lindemuthianum* are resistant to some isolates and susceptible to others, while some lines are resistant to all isolates, and others are susceptible to the great majority of these isolates. Under field conditions, lines such as Ecuador 1056, are resistant to the anthracnose pathogen in all areas where the variety has been evaluated, but it is susceptible to the great majority of isolates at the seedling stage under greenhouse conditions (see Bean Program Annual Report, 1983). This type of mechanism is often referred to as field or adult plant resistance.

We have also observed that some varieties which are susceptible to certain isolates of *C. lindemuthianum* can be induced to have a resistant reaction if they are first inoculated with an isolate that does not cause any symptoms on these varieties. Calima and Cornell 49242 are both susceptible under field conditions in Popayan, Colombia, but under greenhouse conditions they are resistant to some isolates and susceptible to other isolates collected from the field in Popayan. Calima has no reaction, and shows no symptoms when inoculated under greenhouse conditions with the *C. lindemuthianum* isolate Guacas 3, but it is extremely susceptible to the isolate 10-76. Cornell 49242, on the other hand, is extremely susceptible to isolate 10-76 but shows no symptoms when inoculated with isolate Guacas 3.

When Calima is inoculated with a mixture of these isolates, it also shows a susceptible reaction; however, if Calima is first inoculated with the non-pathogenic Guacas isolate, and later with the pathogenic isolate, Calima shows much less disease symptoms. The disease severity in Calima diminishes considerably as the interval between the two inoculations increases (Figure 4). This induced resistance is much more apparent in Calima when it is first inoculated with non-pathogenic isolates, and when the second inoculation with pathogenic isolates is delayed for seven days. Cornell 49242 can also be induced to have the same type of resistant reaction, when first inoculated with the non-pathogenic isolate 10-76 and later with pathogenic isolate Guacas 3, but the induced resistant reaction is not as adequate as that shown by Calima. This type of induced resistance is also known as cross-protection.

A similar induced resistance mechanism has been observed when plants of Cornell 49242 are first sprayed with a liquid suspension obtained from macerating Calima bean plants and later inoculating Cornell 49242 with the pathogenic isolate Guacas 3. Calima is resistant, showing no visible symptoms of anthracnose, to the isolate Guacas 3, and Cornell 49242 is susceptible to this isolate (see Figure 5). When Cornell 49242 is first sprayed with the Calima extract the highest induced resistance is obtained when the inoculation with the pathogenic isolate takes place one hour later. If the inoculation with the pathogenic isolate is delayed the disease severity increases. When the plant extract and the spore suspension of the pathogenic isolate are mixed together and kept for at least two hours before applying it to Cornell 49242, the disease severity decreases considerably. If the mixture is not allowed to sit for a period, before applying it, the disease severity does not decrease as much. Similarly induced resistant reaction was also observed if Cornell 49242 was first inoculated with the pathogenic isolate and immediately after with the Calima extract. The least resistant reaction occurs when longer periods were allowed between the inoculation with pathogenic isolate and the Calima extract application. This seems due to the fact that spores of C. lindemuthianum need several hours for germination and penetration in the plant tissue, and the extract of Calima appears to have a fungistatic effect on the spores of the isolate utilized.

In a different study of disease resistance mechanisms of the bean plant to C. lindemuthianum, three varieties were inoculated separately with a mixture of three isolates of the anthracnose pathogen (Table 8). Each variety was susceptible to only one isolate: Calima to isolate 10-76, Cornell 49242 to Guacas 3, and BAT 841 to Tep. 4. Based on their reaction to many isolates of the anthracnose pathogen, Cornell 49242 is susceptible to a greater number of isolates than the other two varieties, and BAT 841 is resistant to more isolates than the other two varieties. Under field conditions, BAT 841 is also resistant in more locations than the other two varieties.

These varieties had a highly susceptible reaction when inoculated with 1.2×10^6 spores/ml of the isolates that attacked them. However, when the amount of inoculum of the pathogenic isolate was diluted to one half or one third of the original, the more susceptible varieties (Cornell 49242 and Calima) continued to show a susceptible reaction while the more broadly resistant variety BAT 841 had only an intermediate reaction. This type of reaction has also been observed in other varieties wich are resistant to many isolates of C. lindemuthianum, but are susceptible to one or a few isolates.

While evaluations of more varieties are needed, these preliminary results suggest that it may be possible to identify bean varieties with broad resistance to the anthracnose pathogen without having to inoculate them under greenhouse conditions with a great number of isolates, or to evaluate them on the field in many locations where anthracnose occurs. These results also suggest, that for many bean varieties that are evaluated for their resistance under greenhouse conditions, it is more efficient to evaluate them with mixtures of key isolates since the obtained results suggest that high spore concentrations of single virulent isolates do overcome the resistance even of those varieties with broad resistance. Similarly, these results, along with those presented in Figure 4, clearly suggest that in beans inoculated with mixtures of isolates of the anthracnose pathogen, the phenomenon of cross protection (induced resistance) only occurs when a variety is first inoculated with a non-pathogenic isolate and later with a pathogenic one. When a variety is inoculated with a mixture of isolates (some that cause disease and others that do not), the variety does develop disease, often with the same severity had when inoculated with a single pathogenic isolate.

These results are extremely useful in view of the fact that selection for anthracnose resistance in beans in many countries has been conducted under greenhouse conditions utilizing high spore concentration of single pathogenic isolates to inoculate bean seedlings. Under such conditions, the possibility of discarding excellent anthracnose sources does exist if the age of the plant, the amount of inoculum, and the number of isolates used are not carefully considered.

RUST

The methodology previously presented for induced resistance in beans to the anthracnose pathogen has also been used in the study of bean rust caused by Uromyces appendiculatus. The results are fairly similar. Two bean accessions were utilized : ExRico 23 is susceptible to an isolate from Palmira, Colombia, called CIAT (C), however it is resistant (no visible pustules are formed) to an isolate collected from a snap bean variety (Blue Lake) called Pradera (P). Under greenhouse conditions it is possible to protect the susceptible ExRico 23 against the pathogenic C rust isolate, if the ExRico 23 plants were previously inoculated with the P isolate. This protection is not systemic and only those leaf tissues previously inoculated with the non-pathogenic isolate show the induced resistance. These results were obtained under greenhouse conditions.

A trial was also conducted under field conditions in Palmira, utilizing the variety ExRico 23 and the isolates P and C of the rust pathogen. Six treatments were included, each with 3 replications and 4 rows per replication:

1. ExRico was not inoculated or protected.
2. ExRico 23 inoculated with pathogenic isolate C every six days.
3. ExRico 23 protected with isolate P every three days.
4. ExRico 23 protected with isolate P every six days.
5. ExRico first inoculated with P isolate and 3 days later with the C isolate. This was repeated weekly.
6. Ex Rico first inoculated with P isolate and 3 days later with C isolate. This was repeated every 6 days.

There were significant differences in yield between the treatments first protected with the non-pathogenic Pradera isolate and the non-protected treatment that was inoculated only with the pathogenic C isolate (see Table 9). There were no significant yield differences between the other treatments. The lowest yield of the non-protected treatment (1650.0 kg/ha) also corresponded to the highest amount of rust present (AUDPC = 346.67). There were also significant differences in amount of rust between the non-protected treatment and the rest of the treatments. The results of the 100 seed weight and of the number of pods per treatment were similar to those found for yield. The practical significance of these results is being evaluated.

HALO BLIGHT

A second trip to Africa was made in 1986 as part of the collaborative project between the National Vegetable Research Station, (NVRS) in the U.K., and CIAT. The objective was to obtain further samples of the halo blight pathogen, and evaluate the international halo blight nursery (IBHBN), distributed for the first time to three sites in Africa. The lines included in this nursery were selected from the set of 454 cultivars evaluated at NVRS in 1985, and included all the sources of race specific and non-specific resistance identified in 1985. The best nursery, in terms of pressure of halo blight, was at Kisozi, Burundi. At this site, race 3 predominates, and results in the field confirmed that lines with hypersensitive resistance in glasshouse tests were also resistant in the field. Lines with non-specific or intermediate resistance in the glasshouse also showed field resistance. Preliminary conclusions indicate that scores up to 5 in the glasshouse (1-9 scale) will show very adequate levels of resistance in the field.

A cluster analysis based on disease reaction was carried out to compare the eight isolates of halo blight used for screening 454 bean lines at NVRS. The three isolates of race 3 (from Mbeya, Tanzania; Rwerere, Rwanda; and Kasese, Uganda) were very similar to each other, and very different from the other isolates. The race 2 isolates from Colombia (Obonuco) and USA were similar to each other, but the other two isolates of race 2 (from Chapingo, Mexico, and Mbeya, Tanzania) were very different both from each other and from the other isolates. This heterogeneity within race 2 suggests that more differential cultivars eventually will be needed.

It was mentioned in the 1985 report that high priority should be given to finding specific resistance to race 2. It appears that this is available to sub-groups of isolates within race 2. For example, CIAT line ZAA12 was found to be the isolate from Tanzania. This line was selected from the cross between Horsehead and NY76-2812-15, and the latter also showed specific resistance to the USA isolate of race 2, demonstrating that the specific resistance is heritable.

Further screening for resistance to race 4, found on soybeans and occasionally on beans in central Africa, indicates that a high percentage of bean germplasm is resistant (68% of a set of 91 lines tested with two isolates were resistant). A large number of CIAT lines with combined resistance to races 3 and 4 have been identified (e.g. AFR 203, AFR 214, AND 299, AND 367, BRU 2, HAL 1, ZAA 5, ZAA 12, and ZAA 55). Likewise, a number of lines from the Grain Legume Program in Kenya have this combination of resistance (e.g. GLP-X-1150, GLP-X-1135, and GLP-X-1127).

Two strategies are being followed for incorporating resistance to halo blight into important cultivars by backcrossing. For central Africa, it is relatively straightforward to select lines with combined resistance to races 1 and 3. This should cover the present needs for resistance in Uganda, Rwanda, Burundi and Zaire (Figure 1). The second strategy is to incorporate race non-specific resistance, using mainly G 3954 (WIS HBR 72), as the source. This is the more satisfactory solution in the long term, and is needed immediately for Latin American countries where race 2 predominates (Mexico, Colombia, Peru), as well as for Kenya, Tanzania and Zambia (Figure 1). The wide availability of germplasm possessing race-specific resistance, and the ease of selecting for it, make the first a worthwhile short-term strategy.

In crosses to incorporate resistance to races 1 and 3, the segregations in the F_2 generation indicated that dominant genes control resistance to these races, and there was no evidence for linkage between the genes. The gene for race 3 resistance is particularly easy to detect as the reaction on the primary leaves is hypersensitive. No crosses between race 3 resistant parents made so far have segregated susceptible plants, suggesting that the same gene is responsible for resistance in all materials.

The race non-specific resistance of G 3954 has been shown to be controlled by a recessive gene, originating from PI 150414, plus the dominant gene for race 3 resistance. The F_2 segregations observed indicate that these genes are not linked (Figure 2). A number of other sources of race non-specific resistance, described in the 1985 report, appear to have quantitatively controlled resistance : e.g. G 5477 (Gt. Northern 3 #1 sel 27) and G 13673 (Mantequilla).

COMMON BACTERIAL BLIGHT

As with the other fungal and bacterial diseases, advanced and segregating bean nurseries were evaluated during 1986 for their reaction to the CBB pathogen mostly under field conditions in Palmira, Colombia.

An analysis of pedigrees of CIAT lines resistant to Xanthomonas revealed that most resistance in small seeded lines was derived from either PI 207.262 or Nebraska Great Northern sources (Jules and Tara). Therefore, in 1986 an effort was made to diversify sources of CBB resistance in small grained types, incorporating sources such as BAT 1500; XAN 236 and other progeny of G 4399 (Tamaulipas 9-8); BAT 1192 and other progeny of Honduras 46; as well as lines derived from XAN 159, which itself was derived from an interspecific cross.

In larger grain types, it is relatively common to find an intermediate level of resistance in foliage, and there is less problem with genetic uniformity. However, in general this class suffers a greater susceptibility in pods, thus pod inoculation on plants in the field was initiated this year. Hypodermic needles were used to inject inoculum (5×10^7 cells/ml; 5 punctures) into pod wall tissue of young pods at 8-10 days from flowering. Results were as expected, but much variation was observed from pod to pod. Apparently the pod reaction is much less consistent than the foliar reaction. One source of error appears to be the age of pods, with more fibrous pods appearing more resistant. For example, early flowering lines such as Desarrural presented an acceptable reaction, although Desarrural is known to be susceptible in pods. This is no doubt an artifact due to more advanced pod development in the early materials. Nevertheless, lines such as XAN 112 which were previously selected for foliar reaction were also the most resistant in pods. It appears that some elements of foliar resistance are in fact expressed in pods.

Table 1. Reaction of the rust monitor varieties from the International Bean Rust Nursery evaluated from 1975 to 1984 in many bean growing regions of the world.

Monitor Variety	No. of evaluations	Frequency of reaction type[1]			
		Immune	Resistant	Intermediate	Susceptible
Redlands Pioneer	94	12	51	27	3
Redlands Greenleaf B	108	21	50	33	4
Redlands Greenleaf C	100	16	41	39	4
Cocacho	95	15	43	31	6
Mexico 309	108	45	43	13	7
Cuilapa 72-1P (G 4489)	108	33	41	27	7
Ecuador 299 (G 5653)	108	20	41	38	9
Mexico 235	98	26	35	29	9
Turrialba 4 (G 4465)	109	23	31	34	11
Puerto Rico 5	108	25	42	28	13
Compuesto Chimaltenango 3	104	23	53	16	12
Compuesto Chimaltenango 2	104	32	33	24	15
Redlands Autum Crop	98	11	38	34	15
Turrialba 1 (G 4485)	107	19	31	37	20

[1] Evaluations based on a combination of pustule type and percent of foliar area with rust.

Table 2. Reaction of some bean lines with commercial grain color for the Mexican highlands to the rust pathogen in Texcoco, Mexico and Palmira, Colombia.

	Rust reaction[1]	
Bean Line	Texcoco	Palmira
A 177*	3	3
A 197*	3	3
A 440*	3	3
A 441*	3	3
A 114	3	3
A 172	1	3
A 197	1	3
A 252	3	3
A 255	1	3
A 262	1	1
A 266	4	3
A 316	1	3
A 440	1	5
A 445	2	3
EMP 134	3	3
Bayo Mex	1	3
Ojo de Cabra 400	1	3
MAM 7	4	3
BAT 12	4	3
Alteño	1	1
A 293	1	7
MAN 11	8	1

1 Based on a combination of pustule type and percent foliar area with rust; where 1= immune; 3= resistant; 5= intermediate; 7= susceptible 9= highly susceptible. Plots were 4 rows, 6 meters long.

* Evaluated two years in Texcoco.

Table 3. Reaction of selected bean lines to the angular leaf spot pathogen under field conditions in Santander de Quilichao, Colombia.

	Foliage reaction/pod reaction[1]		
Bean Line	1985	1986 A	1986 B
AFR 139	4/3	3/4	4/2
AFR 188	4/2	4/3	4/2
AND 339	6/2	4/3	5/2
AND 373	6/2	2/4	4/3
AND 361	5/2	5/4	5/2
BAT 790	5/4	4/2	4/2
BAT 964	5/4	4/3	4/2
BAT 1276	4/5	4/4	4/2
XAN 42	4/5	4/3	4/2
XAN 122	5/4	4/4	4/1
XAN 195	4/2	4/4	3/2
PVAD.605	4/1	4/2	4/2
ZAA 68	4/4	4/3	4/2
G 8152	5/4	4/1	4/4
Kidney Mottled	3/2	3/2	3/2
RAB 206 (Susceptible check)	7/6	7/6	7/5

[1] Reaction based on 1-9 scale where : 1,2 and 3 are considered resistant; 4,5 and 6 intermediate; and 7,8 and 9 susceptible.

Table 4. Reaction of 13 bean anthracnose differential varieties to isolates of *Colletotrichum lindemuthianum* from Africa.

Variety	Anthracnose Reaction[1]					
	KEN CL-1	TAN CL-3	ZAI CL-5	ZAI CL-2	BUR CL-4	KEN CL-6
Michelite	1.1	1.7	2.8	5.4	9.0	9.0
M.D.R.K	9.0	9.0	9.0	1.7	1.6	9.0
Perry Marrow	1.5	1.0	2.8	4.7	6.5	2.4
Cornell 49242	1.1	1.0	1.1	1.6	1.5	1.3
Widusa	1.0	1.0	1.7	1.0	1.0	1.0
Kaboon	1.0	1.0	1.1	1.7	1.7	1.0
Sanilac	1.0	1.0	2.2	8.0	9.0	1.0
To	1.0	1.0	1.0	6.2	7.6	1.0
Tu	1.0	1.0	1.0	1.0	1.0	1.0
P.I. 207262	1.0	1.0	1.0	7.7	8.0	1.0
AB 136	1.0	1.0	1.0	1.0	1.1	1.0
A 475	3.1	3.0	5.9	1.0/9.0[2]	1.0/9.0[2]	3.1
G 2328	1.0	1.0	1.0	1.0	1.0	1.0
Race group	Beta	Beta	Beta	Brazil I	Brazil I	Mx II

[1] Evaluation scale : 1-9 where 1=no visible symptoms and 9= highly susceptible. Average of ten plants per treatment.

[2] Some plants were immune and others highly susceptible.

Table 5. Reaction of selected bean lines and varieties used for breeding anthracnose resistance for Africa to isolates of Colletotrichum lindemuthianum from Africa.

	Antracnose Reaction[1]					
	KEN	TAN	ZAI	ZAI	BUR	KEN
Variety	CL-1	CL-3	CL-5	CL-2	CL-4	CL-6
Calima	6.7	9.0	7.4	1.1	1.0	9.0
BAT 1386	1.0	1.0	1.4	2.8	3.0	1.0
A 484	3.4	3.4	7.5	1.2	1.0	5.5
A 475	2.5	3.7	4.4	9.0	9.0	3.6
A 240	1.0	1.0	1.0	9.0	9.0	1.3
A 483	3.0	6.1	8.0	1.0	1.0	4.8
A 30	1.0	1.0	1.0	9.0	8.8	1.0
A 252	1.0	1.0	1.0	4.5	4.8	1.0
PVMX 1535	1.0	1.0	1.0	9.0	9.0	1.0
G 2333	1.0	1.0	1.0	1.8	1.0	1.0
Rubona 5	8.6	9.0	7.2	7.3	8.7	8.8
Mutiki 2	8.0	8.3	6.3	1.0	1.0	9.0
Tostado	9.0	9.0	6.4	6.8	5.2	9.0
Kibungo 2	9.0	9.0	9.0	1.8	1.0	9.0
Karama	9.0	9.0	9.0	8.8	8.8	9.0
Habyalimana	1.0	1.0	1.0	1.9	1.6	1.5
Carolina	1.0	1.0	1.0	8.0	1.0/9.0	1.1
Cyunyu	1.0	1.2	1.0	1.9	1.1	1.1
Urinyumba 3	4.8	8.8	7.6	1.2	1.0	3.4
Gisengi 6	6.1	7.3	7.5	3.2	3.9	5.3
Urobonobono	1.3	1.0	1.0	7.7	9.0	1.6
C 10	1.1	1.0	1.0	2.2	3.6	1.5

[1] Evaluation scale : 1-9 where 1= no visible symptoms and 9=highly susceptible. Average of 10 plants per treatment.

Table 6. Reaction of bean anthracnose differential varieties to *Colletotrichum lindemuthianum* isolates from the central and northern bean growing regions of Costa Rica and to the race kappa from Europe.

Bean differential	Anthracnose Reaction[1]						
	ALA[2]	GRE	QUE	CAN	ESP	LIB	KAPPA
Michelite	9.0	9.0	9.0	9.0	8.6	9.0	9.0
MDRK	1.0	1.6	9.0	1.5	1.0	1.0	9.0
Perry Marrow	8.4	8.0	9.0	1.8	1.2	1.0	8.0
Cornell 49242	9.0	9.0	5.4	7.8	9.0	9.0	4.5
Kaboon	1.0	1.0	3.1	1.0	1.0	1.0	1.0
Sanilac	9.0	9.0	9.0	1.0	3.3	1.2	9.0
To	3.0	1.4	1.0	1.2	8.0	2.2	1.0
Tu	2.7	3.9	1.2	1.0	8.0	9.0	1.0
PI 207262	9.0	9.0	1.0	8.3	9.0	1.0	1.0
AB 136	1.1	1.0	1.0	4.2	9.0	5.1	1.2
A 475	2.0	-	2.8	-	1.7	-	-
G 2338	1.0	-	1.0	-	2.3	-	-

[1] Evaluation scale : 1-9 where 1= no visible symptoms and 9=highly susceptible. Average of 10 plants per treatment.

Isolate origin : Central region : ALA = Alajuela; GRE =Grecia QUE = Quepos; Northern Region : CAN = Cañas; ESP = Esparza; LIB = Liberia.

Table 7. Reaction of selected bean anthracnose resistance sources to an isolate of *Colletotrichum lindemuthianum* from the north (ESP) and to two isolates (Que and Ala) from the central region of Costa Rica.

	Anthracnose Reaction[1]		
Variety	ESP	QUE	ALA
G 811	1.8	2.7	1.0
G 984	1.0	1.0	1.0
G 2333	1.2	1.0	1.0
G 2338	2.3	1.0	1.0
G 2641	1.1	1.1	1.4
G 5971	4.6	1.0	1.0
G 6436	2.8	1.0	1.0
G 7148	1.0	3.0	1.0
G 8050	1.0	1.0	1.0
K 2	1.0	1.4	1.0
Princor	1.0	1.0	1.0
Catu	1.1	1.3	1.0
A 293	1.0	4.3	1.0
A 336	1.0	1.7	1.0
A 463	1.0	4.0	1.7
A 483	1.0	6.1	1.2
BAT 1428	1.0	3.8	1.0
EMP 90	6.0	1.0	1.1
Brunca *	7.5	1.4	1.0
Talamanca *	8.5	4.6	3.2

[1] Evaluation scale : 1-9 where : 1,2 and 3 are considered resistant; 4,5 and 6 intermediate; 7,8 and 9 susceptible. Average of 10 plants per treatment.

* Commercial variety.

Table 8. Reaction of three bean varieties to three isolates of <u>Colletotrichum lindemuthianum</u> separately and in mixtures.

	Bean Variety		
Isolate	Calima	Cornell 49242	BAT 841
10-76 (A1)	8.8[1]	1.0	1.4
Guacas (A2)	1.0	9.0	1.0
Tep. 4 (A4)	1.6	1.0	8.4
A1 + A2	9.0	9.0	1.1
A1 + A4	9.0	1.2	3.5
A2 + A4	1.5	9.0	3.3
A1 + A2 + A4	9.0	9.0	3.4

[1] Reaction on 1-9 scale where 1 is without visible disease symptoms and 9 is highly susceptible.

Average of 30 plants evaluated in 3 replications. An inoculum of 1.2×10^6 spores/ml. was used for first 3 treatments, 0.6×10^6 spores/ml for the next three, and 0.4×10^6 spores/ml for the last treatment.

Table 9. Yield, area under the disease progress curve (AUDPC), and 100 seed weight of the bean line ExRico 23 protected under field conditions with a nonpathogenic rust isolate and later inoculated with a pathogenic isolate.

Treatment	Yield (kg/ha)		AUDPC		100 seed wgt (g)	
P 3 C	2956.7	A	36.67	A	17.52	A
P 6	2755.0	A	32.67	A	17.04	A B
N	2431.7	A B	54.08	A	16.73	A B
P 3	2380.0	A B	25.00	A	17.39	A B
P 6 C	2261.7	A B	51.92	A	16.73	A B
C 6	1650.0	B	346.67	B	16.40	B

[1] Treatments : P3C = first inoculated with non pathogenic isolate P and 3 days later with pathogenic isolate C; P 6 = inoculated with P only, every six days; N = Natural, no inoculated with either P or C; P 3= inoculated with P only, every three days; P 6 C = first inoculated with P and 6 days later with C; C 6 = inoculated with C only every six days.

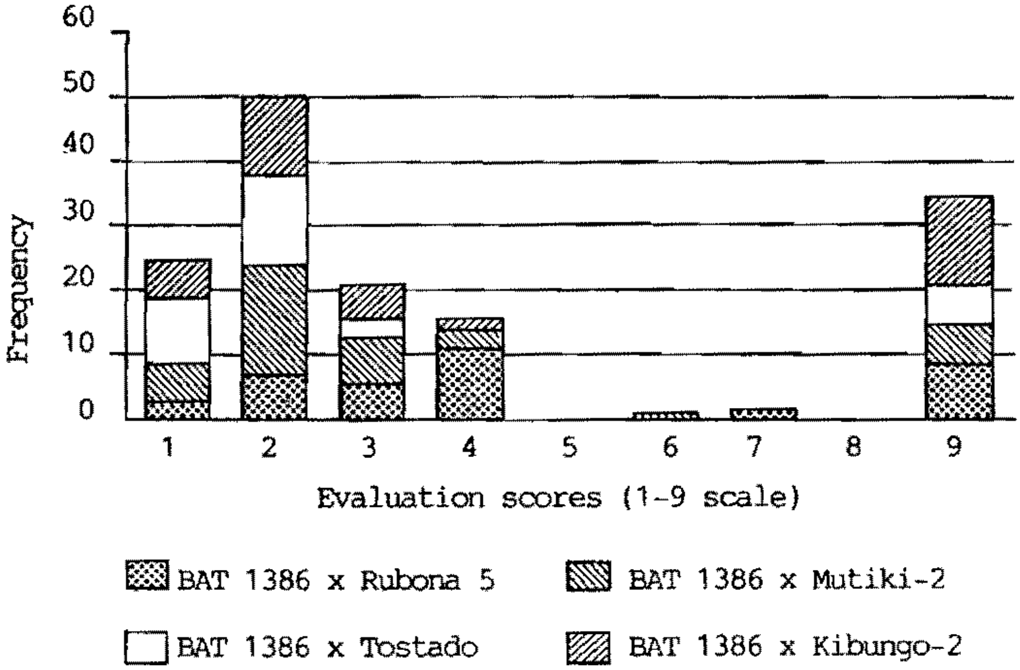


Figure 1. Segregation of F_2 plants of crosses between BAT 1386 (resistant) and four susceptible African cultivars, inoculated with isolate 3 belonging to race group Beta of Colletotrichum lindemuthianum. If plants falling to the left of the discontinuity in the distribution are taken as resistant (score 4 or less), then the total segregation was 112 resistant plants : 38 susceptible plants, which is equal to the segregation expected for a single dominant gene controlling resistance (3:1 ratio).

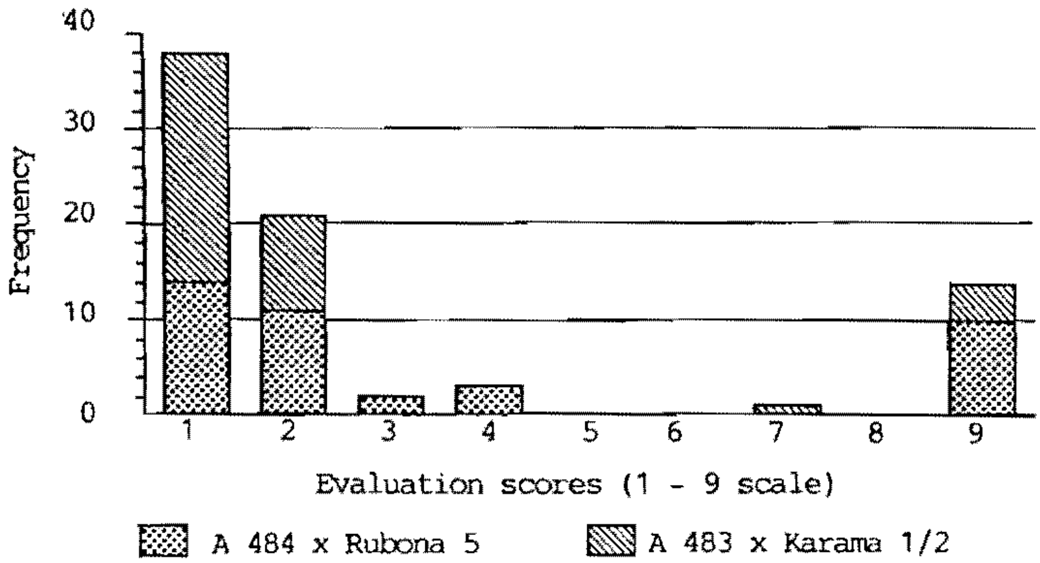


Figure 2. Segregation of F_2 plants inoculated with the Colletotrichum lindemuthianum isolates 4 of race group Brazil 1, using A 484 and A 483 as resistance sources. If the discontinuity at score 4 is taken to define resistance, the segregation is 64 resistant plants : 15 susceptible, compared to an expected ration of 60:19 if resistance is controlled by a single dominant gene.

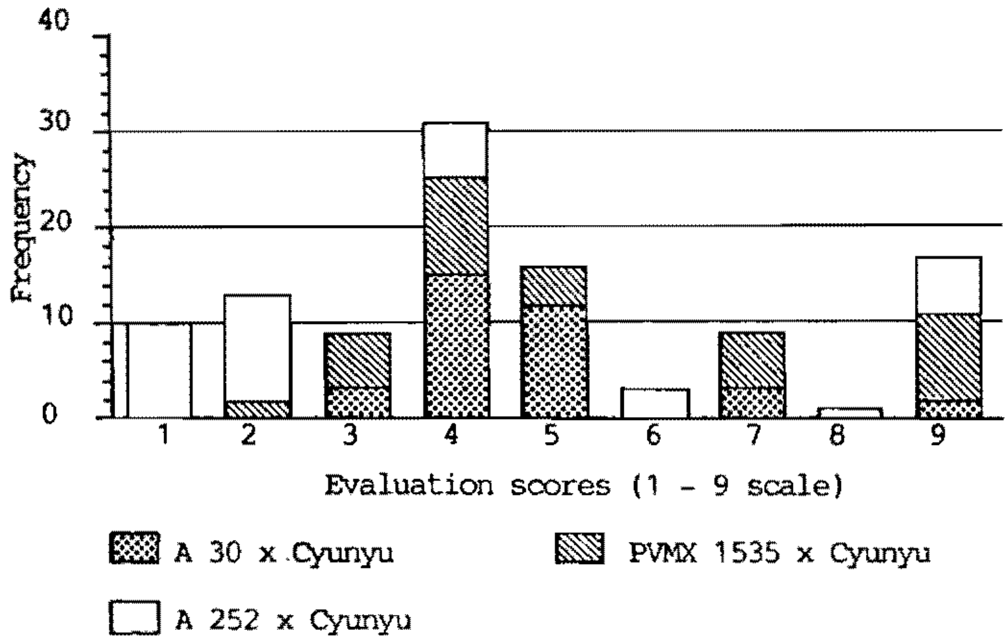


Figure 3. Segregation of F_2 plants in crosses with African resistant cultivar Cyunyu, screened with isolate 4 of race group Brazil 1 of *Colletotrichum lindemuthianum*.

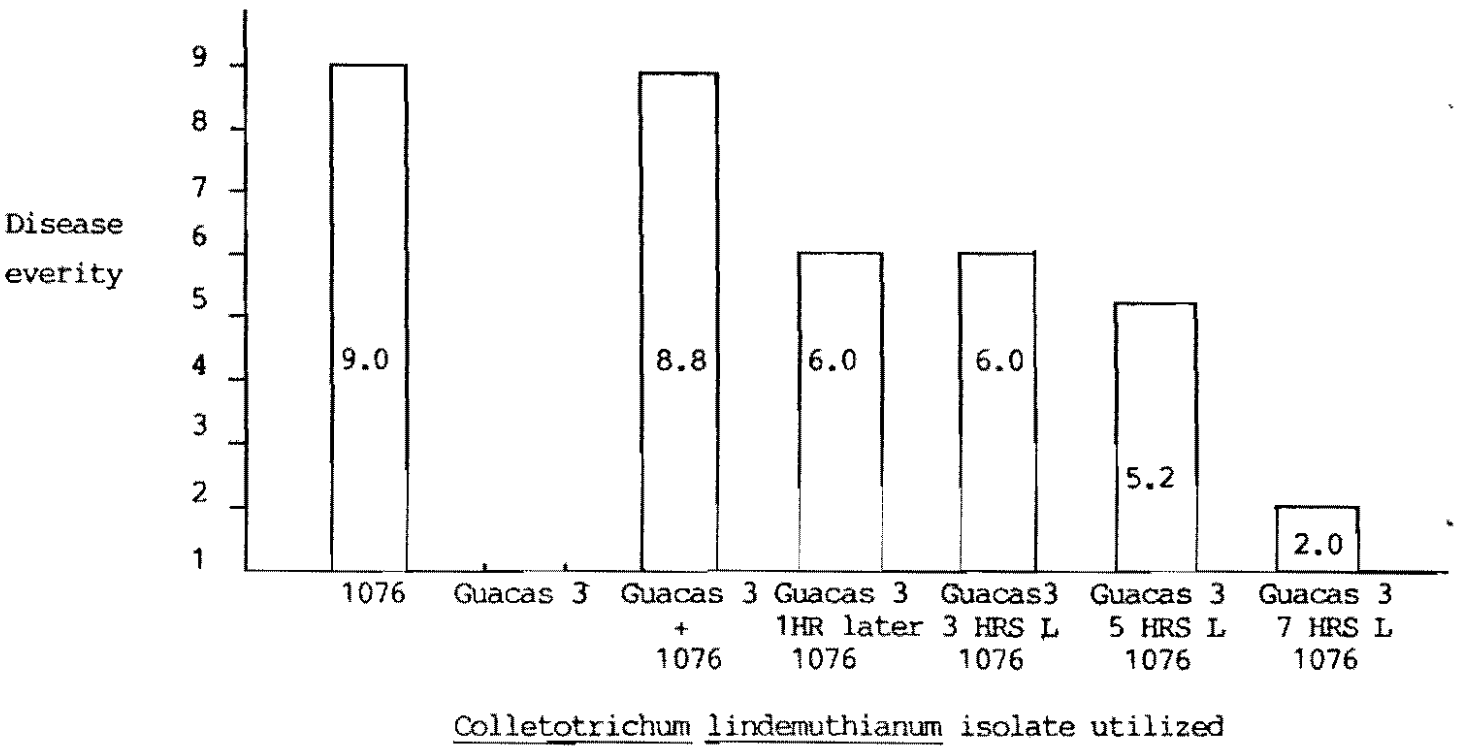


Figure 4. Induced resistance in the bean variety Calima first inoculated with the non-pathogenic isolate of *Colletotrichum lindemuthianum* isolate Guacas 3 and later with the pathogenic isolate 1076.

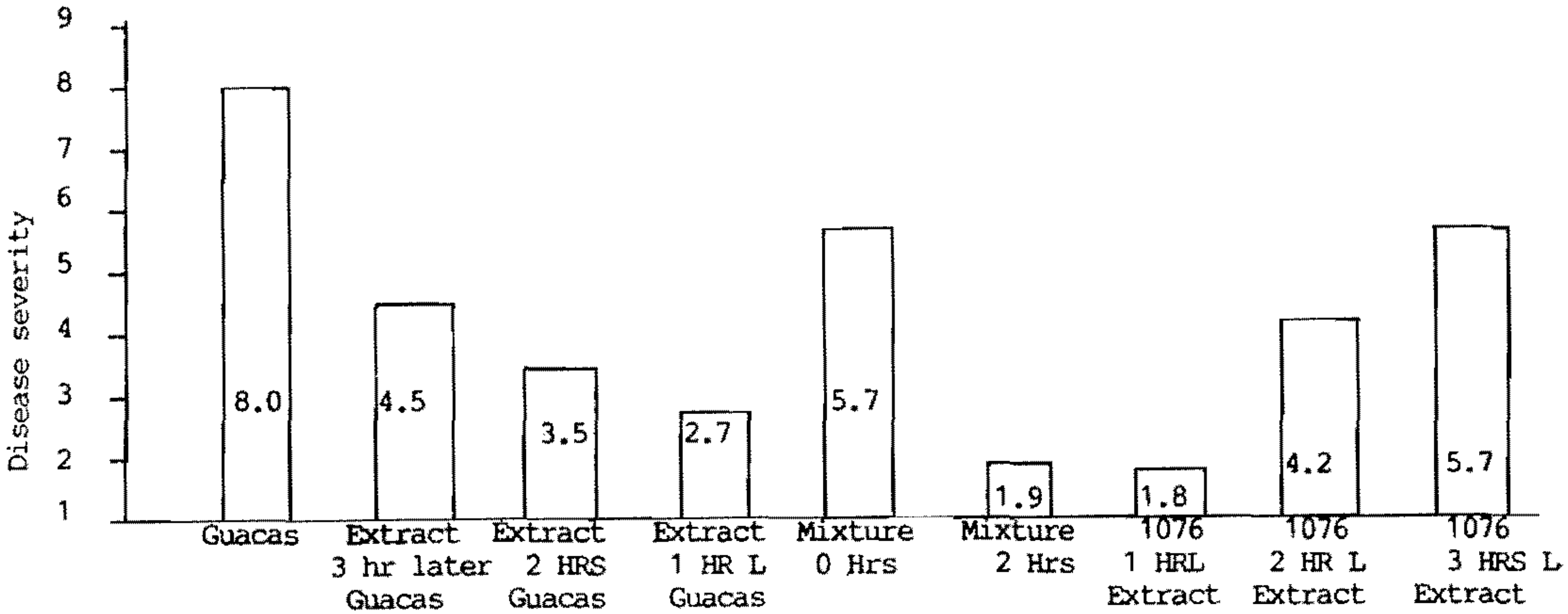


Figure 5. Induced resistance in the bean line Cornell 49242 first sprayed with plant extract of bean variety Calima and then with isolate of Colletotrichum lindemuthianum Guacas 3. Cornell is susceptible to isolate Guacas 3; Calima is resistant.

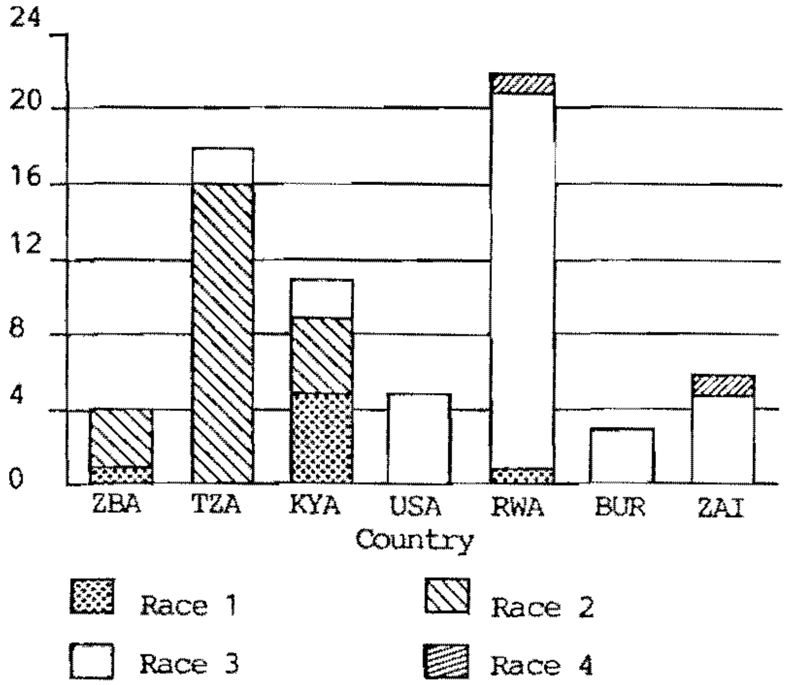


Figure 6. Frequency of races of the halo blight pathogen in samples collected in Africa.

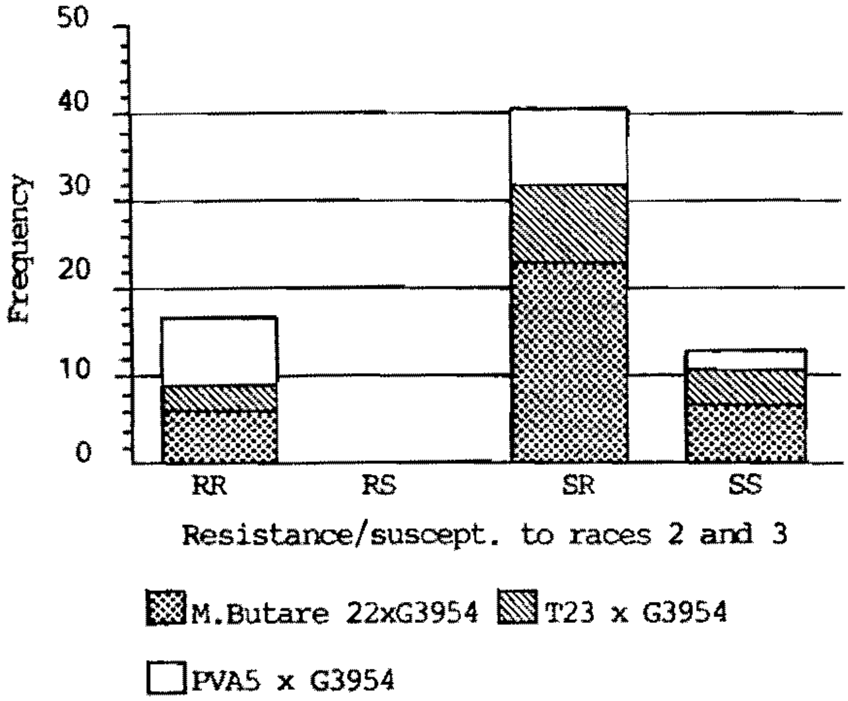


Figure 7. F_2 segregation with races 2 and 3 of the halo blight pathogen.

2. Resistance to Viral Diseases

Bean virus research in the past concentrated mostly on bean common mosaic virus (BCMV). This year research emphasis was shifted to bean golden mosaic virus while BCMV research focused on the incorporation of blackroot resistance in African germplasm, and backcrossing I gene into Latin American varieties.

BEAN COMMON MOSAIC VIRUS

The deployment of the dominant necrosis gene remains a sound strategy to control the incidence and seed-distribution of bean common mosaic virus (BCMV) in Latin America. In 1986, the Bean Virology section screened over 9,300 lines generated mainly by the three breeding sections of the Program. As in the past, selected materials (500 lines) sent to CIAT from National Programs in Argentina, Chile, Mexico and Peru were also evaluated. Screening of improved bean germplasm for black root resistance was intensified as it is now required for all germplasm developed for Eastern Africa.

International bean common mosaic/black root nursery

The susceptibility of most common mosaic-resistant germplasm to systemic necrosis (blackroot) induced by necrotic strains of bean common mosaic virus is of special importance because of the widespread incidence of these strains in Eastern Africa. Consequently an international nursery has been formed which includes as wide a range as possible of resistance sources, including all the strain specific genes known to control resistance in the host. This nursery, in addition to making available a valuable collection of resistance sources for collaborating breeding programs, will enable us to obtain further information on BCMV strain distribution in the field, and the relationship between field and glasshouse evaluations.

Many of the lines included in the nursery were originally selected for their apparent resistance to black root in Africa. These entries were screened at CIAT with necrotic (NL3 and NL5) and mosaic (NL4 and NY-15) strains of BCMV. Lines with contrasting resistance types are shown in Table 1. ZPV 292 was selected originally in Zambia for resistance to black root and mosaic, and the fact that it has resistance like Sanilac suggest that NL3, NL5 or NY15 are not the predominant strains of BCMV in the area of Zambia where it was selected. Two lines from Turkey (common name Horoz Fasulyi; accession numbers G 13077 and G 13089) apparently possess resistance genes like those in Great Northern 31 (susceptible only to NL4). These lines could be valuable sources of the $bc\text{-}2^2$ gene which, when combined with the dominant I gene, confers resistance to all BCMV strains. A number of inoculated lines showed only restricted vein necrosis (resistance) to NL5, but showed plant death (black root) with NL3. Many of these lines are known to perform well in Rwanda (e.g. A 240, A 411, BAN 6, XAN 76, ZAV 83009), suggesting that resistance to NL3 may be sufficient in some areas, although this unexpected reaction is still under investigation. The reverse situation, resistance to NL3 but plant death with NL5, occurs in cultivars like Red Kloud (G 76), Redkote (G 4807) and A 195, and also appears to confer field resistance in Rwanda. Restricted vein necrosis (resistance) to both NL3 and NL5, was found in A 197, A 484, BAT 841 and BAT 1426, all known to be black root-resistant in Africa. The combination of dominant I gene plus bc-2^2, conferring resistance to all BCMV strains, is found in CIAT lines MCM 1002, PAC 13, PAN 145 and BLM 74.

An alternative strategy for resistance to all known BCMV strains is the single recessive gene bc-3. This gene is very easy to incorporate by backcrossing, and it shows no unfavorable linkages with seed color, unlike the dominant I gene, which has always been difficult to combine with clear colors like red and yellow. A large number of lines are now available with this gene.

<u>Incorporating resistance to black root by backcrossing</u>:

Three major strategies are being followed for incorporating resistance to black root in major African cultivars. These are: dominant I gene plus bc-2^2 (possibly the ideal combination, limited by linkage problems with seed color); dominant I gene plus bc-1^2 (a relatively common gene combination probably found in large seeded bush cultivars like Red Kloud, and therefore, easy to work with in the short term); recessive I^+ gene plus bc-3 (no color linkage problems, easy to select, and perhaps especially suitable for highland climbers).

Using cultivars either originating or selected in Africa, 133 crosses with black root resistance sources were made and screened in the F_2 generation in the glasshouse with a mixture of NL3 and NL4 strains. In total, 2,973 plants were screened, and of these 148 (5%) were selected for local vein necrosis (dominant I plus recessive bc gene), and 198 (7%) were selected for absence of symptoms (bc-3 gene). The selected plants were transplanted to the screenhouse, and were backcrossed onto the African parents. The same crosses were sent to Rwanda, and were selected for resistance to mosaic and black root under field conditions, for eventual comparison with the glasshouse selections.

A phenomenon noted in the selections was slow development of black root, particularly in crosses with Red Kloud and Redkote (probably, dominant I plus bc-1^2 genes). Since this gene combination does not give complete resistance to black root, possibly other genes control the rate of development of systemic symtoms, which may appear even after flowering. The crosses with sources of bc-3 gene produced a slightly higher that expected number of resistant plants, possibly due to the existence of symptomless, susceptible plants. Otherwise, handling these crosses is straightforward, and this gene will be available in a wide range of African germplasm shortly.

but many possessed acceptable levels of BGMV tolerance. A second evaluation of these selected materials and 895 new entries is underway at the same locations. The best selections will be evaluated next year in Brazil and Argentina.

At the applied research level, emphasis was also placed on the isolation of a mechanically- transmissible BGMV isolate for artificial screening and pathogenicity studies. To date, three BGMV isolates from Colombia, Guatemala, and Mexico have been isolated by mechanical means. Similar efforts to recover Argentinian, and Brazilian isolates (a cooperative CRSP project with CNPAF and Univ. of Wisconsin), were unsuccessful despite repeated attempts. Considering the similar inoculation methodology followed in all cases, the different transmission properties constitute a noticeable difference between the Central American and South American BGMV isolates.

A mechanically-transmissible CIAT isolate was used to artificially screen bean germplasm of known field reaction. Table 3 shows the results of the comparative field (in Guatemala) and glasshouse evaluation of 25 varieties and bred lines. As can be observed, the artificial and natural evaluations yielded surprisingly similar results. For instance, the results of the artificial inoculation test of experimental lines A 429 and DOR 303, confirmed their high level of field tolerance. A 429 produced acceptable yield despite the BGMV infection and DOR 303 tended to escape infection. As observed in the field, DOR 303 plants which become infected, exhibit severe symptoms. In relation to these two lines, it is interesting to point out that none of their progenitors (Cacahuate 72, Garrapato, G 2115, Moeda, Red Kloud or Porrillo Sintetico) exhibits a higher level of resistance than either A 429 or DOR 303 (Table 3) suggesting the existence of transgressive segregation. The Great Northern lines 31 and 164557 (Blanco INIA) showed a high level of tolerance to artificially-inoculated BGMV, under glasshouse conditions.

Besides these resistance mechanisms, we studied in more detail the local lesion resistance mechanism reported last year for Red Mexican 35. The tests carried out this year with this red-seeded genotype confirmed its ability to react hypersensitively and to resist a moderate level of inoculum. Although this type of resistance can be overcome in the field, we have circumstantial evidence indicating that Red Mexican 35 possesses valuable genes which should be used in breeding programs. Another valuable genotype found in these studies was Redlands Greenleaf-C,(Table 3) a variety which, despite its susceptibility to BGMV and typical symptom expression, is neither significantly stunted nor affected by pod distortion, thus yielding acceptably. This and other similar genotypes, such as some Red Kidney varieties which maintain their morphological characteristics despite the systemic BGMV infection, should also be used to control plant stunting, one of the main yield-depressing symptoms induced by BGMV.

One of the most interesting observations made during the artificial screening of bean germplasm was the critical effect of seedling age at inoculation time on the susceptibility of a genotype to BGMV (Table 4), this sometimes being evident within a matter of hours.

(Figure 1). These preparations were injected in rabbits to produce an antiserum which can now be used to detect the virus in infected plants using regular agar-immunodiffusion tests. The antiserum has also been used to detect BGMV by the serologically specific electron microscopy (SSEM) technique. However, this type of polyclonal antiserum cannot be used to differentiate BGMV from related bean geminiviruses, such as bean chlorotic mottle, due to the unusual close serological relationship which exists among these geminiviruses transmitted by the whitefly *Bemisia tabaci*.

Cytological studies

A comparative cytopathological study of selected BGMV isolates is underway to characterize different geographical isolates in order to study their pathogenic behavior in susceptible and tolerant bean genotypes. Although this research was recently initiated, the cytopathic effects of the virus in infected bean cells have already been visualized (Figure 2), confirming the characteristic tendency of BGMV to invade the nucleus and, hence, induce severe symptoms in infected plants.

BEAN CLOROTIC MOTTLE VIRUS

Bean chlorotic mottle virus (BCLMV) was recognized in 1981 as a potentially important bean virus. BCLMV greatly affected bean production in northwest Argentina, an important producer of beans for the Latin American market, but the disease has been effectively controlled through the implementation of an integrated control approach consisting of: 1) the use of tolerant germplasm now grown on over 100,000 hectares, 2) the zoning of the main whitefly host (soybean) and bean fields in the affected areas, and 3) the use of economic levels of insecticides applied to control the insect vector in the early stages of plant development.

BCLMV and BGMV are both transmitted by the same whitefly species and both their coat proteins and nucleic acids are closely related. Whether these pathogenic variants can arise spontaneously from endemic strains present in wild hosts is now being investigated. Various BCLMV isolates have been made and are currently being characterized. Preliminary results suggest that BCLMV and BGMV are more intimately related than previously thought, and that BLCMV can induce golden mosaic symptons in bean genotypes inoculated successively with this virus.

Table 1 (continuation)

Identification	NY-15	NL-4	NL-3	NL-5
G 5173		0	N^{++}	N
G 6384		M	LA	LA
G 6719		0	N	N^{++}
G 8074		0	N^{++}	N^{+}
G 12685	0	M	M	M
G 13077		M	LA	LA
G 13089		M	LA	LA
G 13936		0	0	0
GN-164557		0	PPL	PPL
GN-31		M	LA	LA
IVT 7214		0	0	0
IVT 7233		0	PPL	PPL
IVT 80785		0	0	0
MCM 251-1		0	0	0
MCM 251-10		0	0	0
MCM 251-11		0	0	0
MCM 251-2		0	0	0
MCM 251-3		0	0	0
MCM 251-4		0	0	0
MCM 251-5		0	0	0
MCM 251-6		0	0	0
MCM 251-7		0	0	0
MCM 251-8		0	0	0
MCM 251-9		0	0	0
MCM 1002		0	PPL	PPL
MCR 251-5		0	0	0
MCR 251-6		0	0	0
MCR 251-8		0	V	0
MCR 251-9		0	0	0

Table 2. Number of bean germplasm accessions selected under natural bean golden mosaic virus incidence. Classified by grain type and evaluation site.

Grain type	Number of accessions (Selected/total) Guatemala	Mexico
Pinto	47/347	24/347
Red Kidney		
- light	26/52	8/52
- dark	43/76	8/76
Great Northern	20/20	-
Geminivirus-resistant	13/66	12/66
Exotic germplasm	29/204	20/204

Table 4. Effect of plant age on the susceptibility of the bean variety Porrillo Sintetico to bean golden mosaic virus by artificial inoculation.

Seedling age	BGMV infection Trial 1	BGMV infection Trial 2
Days	%	
7[a]	100[b]	100
8	80	100
9	50	90
10	20	60
11	0	50
12	0	0
13	0	0

[a] Days from sowing.

[b] Ten plants mechanically inoculated per sowing date.

Figure 2. Ultrathin section of Golden Mosaic-affected bean leaf showing geminivirus particle aggregates and ring-shaped inclusions (arrow) in the cell nucleus. Magnification: X 7500. Inset shows enlarged nuclear virus particle aggregates (v) and fibrillar rings. Magnification: X 50,000.

Breeding for resistance in determinate bush beans

Determinate bush beans are particularly difficult to improve for resistance to leafhoppers. Nevertheless, the search for sources of resistance continued and crosses within this group were made in 1984. Following selections in early segregating populations, 96 F_5 lines were yield tested in 1986 under high insect pressure and 18 of them were selected for resistance, color and seed size, and yield tested again. Table 2 shows the performance of those lines which significantly out-yielded the commercial checks. These data suggest that significant progress has been made in incorporating resistance into medium-to-large seeded type I materials.

Cycle VIII (indeterminate bush beans)

Following progeny-row testing in F_5, 50 lines were yield tested in F_6 under severe leafhopper infestation (average yield loss = 66.1%). The best lines were selected on the basis of nonprotected yield and percent yield loss (Table 3). In terms of nonprotected yields, only one line was statistically superior to ICA Pijao, the tolerant check. In terms of percent yield loss, several were better than the checks. Nevertheless, these results suggested the need to increase selection pressure within the modified recurrent selection program adopted in 1985. A comparison between selection practices, individual plant selections in F_2 vs. individual plant selections in F_5, is now in progress. Simultaneously, new breeding materials in the F_3 and F_6 stages will be yield tested in 1987.

The search for new sources of resistance among germplasm materials was intensified. A total of 2663 accessions were evaluated, but only 71 were rated as resistant. Of these, only 13 were resistant in reconfirmation tests, and some were included in the 1986 B crossing block, together with six materials identified in the 1986 VEF and EP nurseries.

BRUCHIDS

Screening for resistance

The search for additional sources of resistance continued. When 90 wild accessions of Mexican origin that had not been previously studied were screened, three accessions (G 12947, G 12950 and G 12951) were highly resistant to *Zabrotes subfasciatus* and nine (G 09989, G 12858, G 12916, G 12943, G 12947, G 12950, G 12963, G 12978 and G 12984) were classified as highly resistant to *Acanthoscelides obtectus*. Simultaneously, 61 accessions were evaluated for *Z. subfasciatus* in replicated reconfirmation tests. Five of these were intermediate in resistance. The others were susceptible. High levels of resistance to *A. obtectus* were reconfirmed in 42 additional entries. Very high levels of resistance to both species of bruchids were also found among *Phaseolus acutifolius* accessions.

well with percentage seeds perforated (r=0.71; P 0.01) and perforations/seed (r=0.83; P 0.01). As with Z. subfasciatus, the practice of mass selections in early segregating populations has been discontinued.

Arcelin, a novel protein found only in certain wild P. vulgaris accessions, has been reported as a factor conferring resistance to bruchids. Seven genotypes, selected by Dr. Fred A. Bliss (CRSP project, University of Wisconsin, USA) for the presence or absence of arcelin were evaluated for resistance to Z. subfasciatus and A. obtectus. The results indicated that arcelin content seems to be an important factor conferring resistance to Z. subfasciatus as lines with this protein were resistant (Table 11). SDS-PAGE electrophoresis confirmed the presence of arcelin in the three resistant lines (859446-67, 859446-71 and 859445-20) (Figure 3). On the other hand, arcelin content was not found to be associated with resistance to A. obtectus, as these lines were all susceptible to this species (Table 12). A carbohydrate has been proposed by researchers at the University of Durham as the factor possibly responsible for resistance to A. obtectus, and this theory needs further study.

Significant progress was made in the characterization of arcelin types through electrophoresis. This technique will be extensively used to make individual plant selections in F_2 and following generations of simple crosses and backcrosses already made in 1986 B. Electrophoresis, coupled with feeding tests, is expected to accelerate the progress incorporating resistance to bruchids. Progress was also made in successfully rearing both species of bruchids in "artificial" seeds and gelatin capsules, techniques which are being utilized in detailed studies on mechanisms of resistance.

As the levels of antibiosis found in some P. vulgaris wild accessions are high, it was felt necessary to study possible antinutritional and/or toxic effects of the most resistant materials. White mice of both sexes fed G 12891 (wild, resistant) gained as much weight as those fed Calima (commercial variety in Colombia) or Purina (a commercial diet). No toxic effects were detected. These results coincided with tests carried out with rats at INCAP in Guatemala (Dr. Ricardo Bressani) and at Michigan State University ,(Dr. George Hosfield) both of whom independently concluded that the arcelin protein in cooked beans is not toxic to rats . Human feeding trials are in progress at the Universidad del Valle, Colombia.

WHITEFLIES

Studies on the biology, some aspects of the ecology, and mass rearing of whiteflies were initiated in 1986. Both Bemisia tabaci (Gennadius) and Trialeurodes vaporariorum (Westwood) breed on beans at CIAT. B. tabaci appears earlier in the season and prefers to oviposit on cotyledonal leaves whereas T. vaporariorum appears just before flowering and lays most of the eggs on trifoliate leaves. Studies on the effect of planting dates and observations through the dry season revealed that the best time to sample for white flies would be 30-35 days after planting on cotyledonal leaves for B. tabaci and 40-45 days

The *Apion* work in Central America was greatly strengthened in 1986 by the contracting of an agronomist to attend to entomological studies. This will assure continuity of work initiated previously. In addition to resistance screening, studies have been initiated on effect of date of planting; methods of measuring *Apion* populations; nursery design; and insect biology.

Table 2. Best F_6, determinate, bush bean lines from a recurrent selection cycle for resistance to *Empoasca kraemeri* (means of three replications).

Lines	Color	100-seed weight (g)	Yield (kg/ha) Nonprotected	Yield (kg/ha) Protected	% yield reduction
EMP 177	Red, mottled	29	1114	1440	22.6
EMP 178	Red, mottled	34	1102	1824	39.6
EMP 179	Pink, mottled	25	903	1674	46.0
EMP 180	Red, mottled	34	824	1805	54.3
EMP 181	Red, mottled	38	816	2025	59.7
EMP 182	Red, mottled	33	807	1420	43.2
EMP 183	Red, mottled	35	786	1507	47.8
EMP 184	Red, mottled	34	776	1809	57.1
EMP 185	Red, mottled	30	749	1763	57.5
EMP 186	Dark red	26	718	1426	49.6
BAT 1366[1)]	Red, mottled	32	404	1361	70.3
Line 24[1)]	Red, mottled	39	365	1172	68.8
ICA P11[1)]	Red, mottled	35	459	971	52.7
LSD 5%			254	435	
C.V.(%)			22.6	17.2	

1) Susceptible

Table 4. Levels of resistance to *Zabrotes subfasciatus* in F_5 individual plant selections (laboratory conditions[1]), means of three replications).

Identification	Parents	Eggs/seed	Progeny/ female	Life cycle (days)	Weight/ adult ($g \times 10^{-3}$)	% emergence	Classification
GC7-7	ICA Viboral x G 12952	4.5	9.0	47.4	0.8	28.1	Intermediate
GC8-11	ICA Radical x G 12952	5.8	19.5	50.0	0.7	47.0	Intermediate
GG9-3	G 10019 x G 12891	3.8	6.3	48.2	0.8	23.5	Resistant
G 12952	(Resistant check)	1.6	0.6	50.3	0.9	5.9	Resistant
Calima	(Susceptible check)	5.8	33.4	31.6	1.4	80.8	Susceptible

[1] 50 seeds/replication infested with 7 pair of *Z. subfasciatus*

Table 6. Best F_5 lines of crosses between cultivated and resistant wild Mexican materials evaluated for resistance to A. obtectus under field conditions (means of three replications; 50 pods at random per replication).

Identification	Parents	Percentage Pods perforated	Percentage Seeds perforated	Adults/ seed	Weight/ adult ($g \times 10^{-3}$)	Classification[1)]
22P2	BAT 1274 x G 12952	23.8	20.2	0.5	1.7	I
23P5	EMP 84 x G 12952	21.6	19.4	0.4	1.9	I
22P35	BAT 1274 x G 12952	19.2	15.9	0.3	1.6	I
15P19	G 12891 x G 04017	17.7	14.3	0.4	1.7	I
6P14	V 79020 x G 12891	14.3	17.4	0.4	1.6	I
15P35	G 12891 x G 04017	13.5	12.6	0.3	1.9	R
G 12952	(Resistant check)	14.2	14.8	0.2	1.4	R
G 12891	(Resistant check)	12.2	14.5	0.3	1.7	R
G 10019	(Resistant check)	6.2	8.1	0.1	1.6	R
V 80030	(Susceptible check)	46.8	37.4	1.1	2.4	S
V 79020	(Susceptible check)	35.5	25.7	0.9	2.4	S

1) I = Intermediate; R = Resistant; S = Susceptible

Table 8. Oviposition of *Zabrotes subfasciatus* on seeds of varying sizes and resistance levels mixed in equal amounts to simulate an F_2 population (free-choice test/means of 16 replications/600 seeds/mixture infested with 94 pairs/replication).

Accession	Characteristics	100-seed weight (g)	% seeds with eggs	Eggs/ seed
A 36	Cultivated, susceptible	45.0	99.7[1] a	17.8 a
Pijao	Cultivated, susceptible	24.0	91.4 b	5.1 c
G 02540	Cultivated, susceptible	21.0	99.0 a	9.3 b
G 12924	Wild, intermediate	15.7	72.5 c	1.8 d
14P18	Cultivated, intermediate	14.0	43.4 d	0.8 e
G 12891	Wild, resistant	10.1	9.7 g	0.1 gh
6P14	Cultivated, resistant	10.0	25.5 e	0.4 f
3P4	Cultivated, intermediate	10.0	38.9 d	0.7 e
G 10011	Wild, susceptible	8.4	15.6 f	0.2 fg
G 12952	Wild, resistant	7.3	2.4 h	0.02 h
G 11051	Wild, intermediate	6.6	7.2 g	0.1 gh
G 12861	Wild, susceptible	4.7	8.7 g	0.1 gh

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

Table 10. Seed penetration by first instar larvae of *Acanthoscelides obtectus* in an F_2 population simulated by mixing accessions of varying sizes and resistance levels (means 16 replications/600 seeds/accession infested with 60 pairs/replication).

Accession	Characteristics	100-seed weight (g)	% seeds perforated	Perforations seed
A36	Cultivated, susceptible	45.0	83.7 a[1)]	1.70 a
Pijao	Cultivated, susceptible	24.0	69.7 b	1.02 b
G 02540	Cultivated, susceptible	21.0	61.9 c	0.92 b
14P18	Cultivated, intermediate	14.0	48.5 d	0.59 d
15P19	Cultivated, resistant	12.0	32.7 e	0.37 e
3P4	Cultivated, intermediate	10.0	51.4 d	0.67 cd
G 10011	Wild, susceptible	8.4	20.9 f	0.22 fg
G 12952	Wild, intermediate	7.3	16.0 f	0.15 gh
G 12888	Wild, intermediate	6.9	60.2 c	0.72 c
G 10007	Wild, resistant	6.5	21.0 f	0.21 g
G 10019	Wild, resistant	5.3	31.0 e	0.32 ef
G 12861	Wild, susceptible	4.7	11.0 g	0.11 h

1) Means followed by the same letter are not significantly different at the 5% level.

Table 12. Levels of resistance to Acanthoscelides obtectus in lines selected for arcelin contents at the University of Wisconsin (Means of five replications; 50 seeds/replication, infested with 100 eggs).

Line	Arcelin contents	100-seed weight	% emergence	Life cycle (days)	Weight/ adult ($gx10^{-3}$)	Rating[1)]
859446-67 (Pinto)	+	34	74.4 a[2)]	39.1 c	2.3 bc	S
859446-59 (Pinto)	-	37	86.0 a	33.5 e	2.6 a	S
859439-11 (Pinto)	-	34	85.6 a	33.5 e	2.6 a	S
859446-71 (Pinto)	+	34	65.4 ab	38.6 c	2.3 b	S
85944668 (Pinto)	-	36	84.6 a	33.7 e	2.6 a	S
R-148-15 (Red)	-	24	85.4 a	33.9 e	2.6 a	S
859445-20 (Red)	+	17	53.6 b	42.9 b	2.2 c	S
G 12952 (Res. check)		5	1.6 c	51.7 a	1.1 d	R
Calima (Susc. check)		50	74.0 a	36.0 d	2.4 b	S

1) R = Resistant; S = Susceptible

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

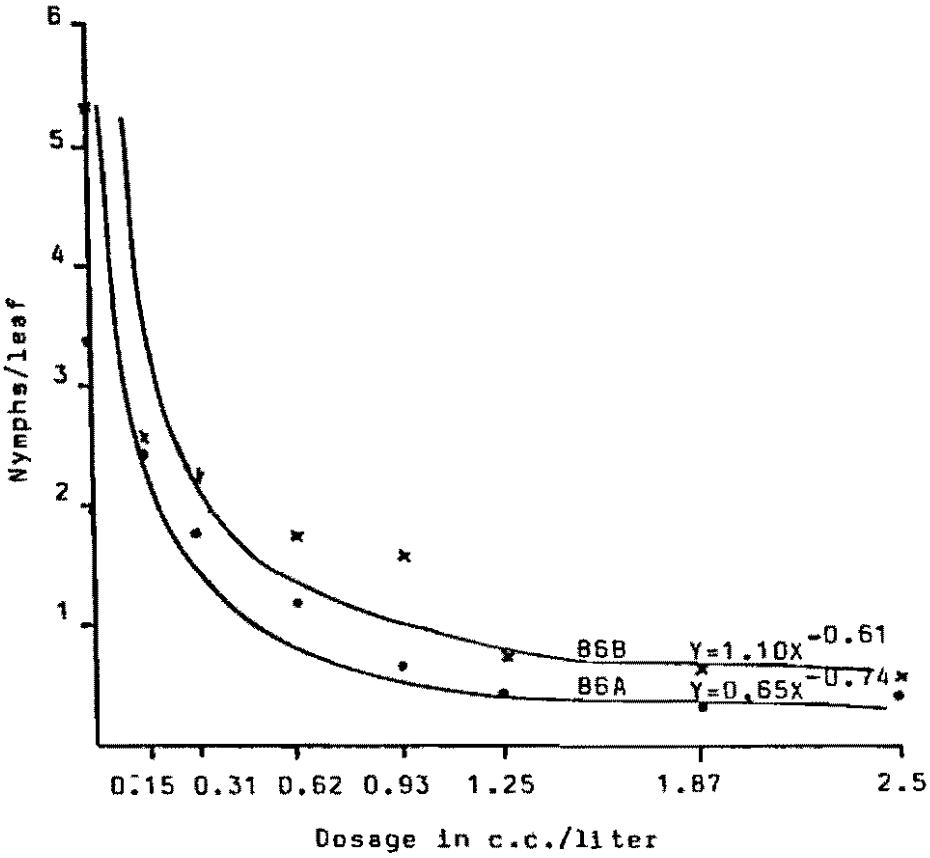


Figure 1. Effect of increasing dosages of monocrotofos on leafhopper populations.

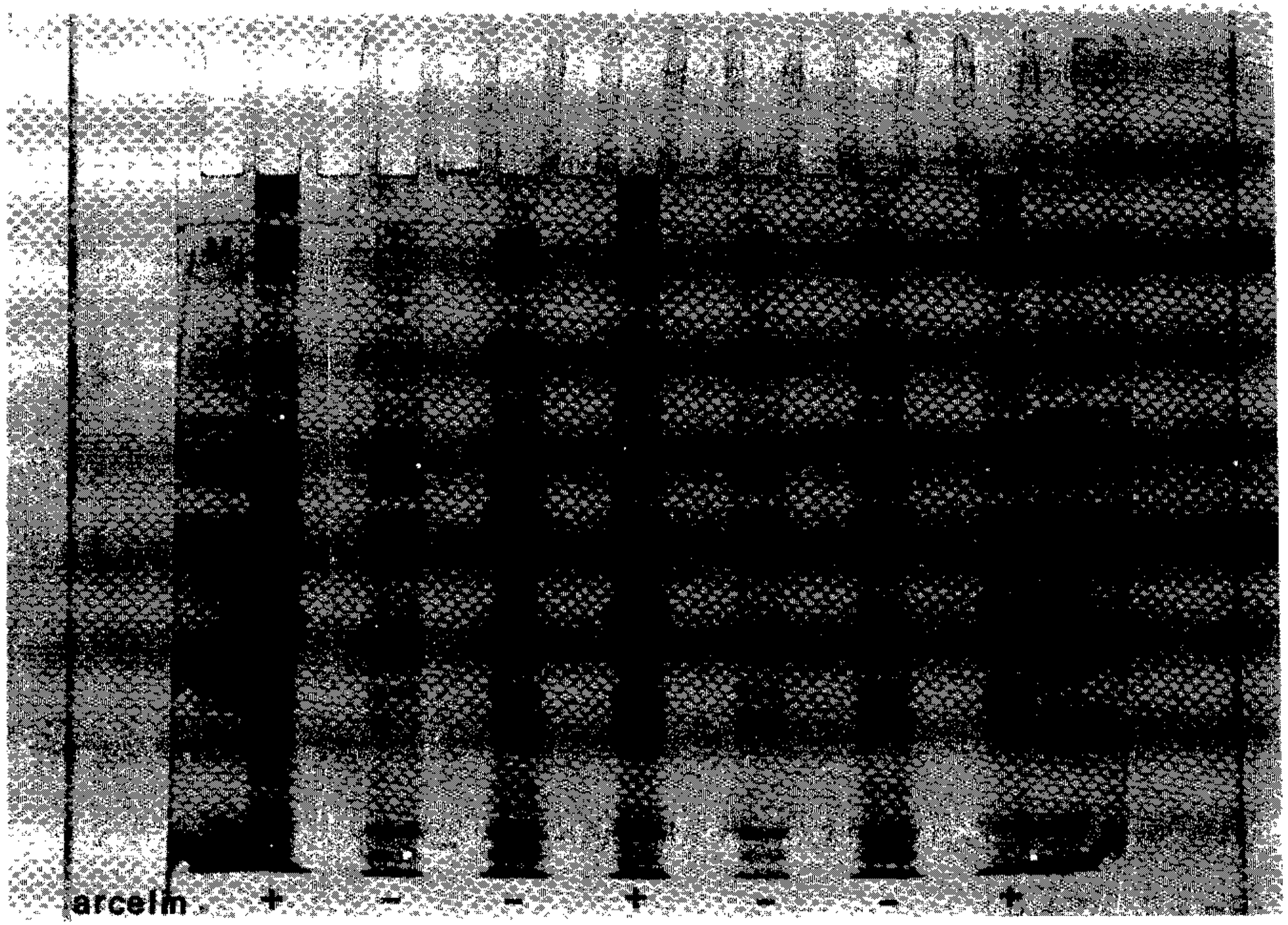


Figure 3. SDS PAGE electrophoresis of lines selected for arcelin contents at the University of Wisconsin.

B) Beans are sink limited, and thus there is little relation between pod set and leaf area (a measure of source strength).

C) Beans are source limited, and thus there is a strong negative correlation between pod set and leaves remaining at maturity.

In Figure 1, data for leaf weight at maturity (relative value as fraction of total plant dry weight) vs reproductive dry weight (relative value including weight of pods removed during depodding) are seen to support hypothesis C. This conclusion was further reinforced by similar results obtained with BAT 881, and by the apparent insensitivity of the results to the three different dates of pod removal. The principal doubts concerning the hypothesis are how closely the results reflect patterns of N mobilization, and whether bean genotypes exist (such as supposed "non-senescing" lines) which do not show this pattern.

Throughout these experiments, and indeed most bean yield trials at CIAT, lodging has been a severe confounding factor. Although lodging was shown to be important as early as 1976 (1976 CIAT Annual Report), subsequent progress in reducing lodging has been slow. A few erect lines are moderately lodging resistant, but there is much room for improvement. To better understand the effects of lodging, future density and nitrogen experiments will include treatments using artificial supports to minimize effects of lodging. At the same time, the need to continue searching for erect, non-lodging lines is apparent.

In the past year, this search was begun by visually selecting promising materials in breeders' nurseries and the VEF, where plants are grown at 0.6 m spacings. Selected lines were then yield tested at 0.3 m with 30 plants/m^2 populations. Yields at 0.6 m either in nurseries or yield trials were considered irrelevant since it is presumed that ability to yield at 0.6 m results from a level of vegetative vigor that may be detrimental at the 0.3 m spacing. Promising materials from the yield trials at 0.3 m are listed in Table 3.

Seed size effects

In the domestication of many crops, increased organ size has been associated with greater tissue cell size. However, greater cell size has also been linked with undesirable characteristics such as reduced drought tolerance and lower leaf photosynthetic rates. Thus cultivar differences in cell size might explain lower yield potential of large seeded bean cultivars. To test whether seed size and tissue cell sizes were correlated in beans, cell sizes in various tissues were measured in 15 bean accessions, including two of subsp. aborigineus with very small seeds (less than 0.05 g). Cell sizes were estimated as approximate volumes based on widths and lengths of cells in cross section. The results bore out the expected relation although exceptions occurred (Table 4). The negative correlation of pallisade yield reduction. To better understand the limitations of early varieties, and to identify parameters to increase their yield potential, a growth analysis of 16 genotypes of varying maturity was carried out in two distinct planting seasons. The first season (Experiment A) can be described as suboptimal, judging from the overall performance of the materials (Table 6), while the second season (Experiment B) was near optimal (Table 7). Thus the conclusions are based on two contrasting seasons. Parameters measured included size (eg. leaf area index - LAI) and efficiency (eg. crop growth rate - CGR).

The yielding advantage of late materials was again confirmed, as the correlation of days to physiological maturity (DPM) and yield was significant in both epochs (r = .67** and .57*, A + B). Likewise, parameters of size were generally correlated with both DPM and yield (Table 8). From this one might conclude that yield is basically a function of size, or source capacity. This may have been true in Experiment A, but, in Experiment B, most early genotypes approached or attained an LAI of 4 (usually considered optimal for beans), while late genotypes exceeded the level considerably. In Experiment B early materials were not limited so much by size (this being near optimal for LAI) but rather by the available period for growth.

Focusing on the division of the growth cycle into a vegetative period (days to flower - DF) and a reproductive period (pod filling period - PFP), it appeared that the length of the PFP is more critical in determining yield. The correlation between DF and yield was .40 and .37 (A and B, respectively), while PFP and yield had correlations of .74** and .61* (A + B). In terms of yield components, PFP may have only a slight effect on seed per pod (r = .19 and .43, A + B) but contributes more to seed size (r = .53* and .54*). When these components were multiplied to give a component of yield per pod, the correlation with yield increased to .73** and .70**. In other words, a longer pod filling period resulted in better filled pods, as would be expected. The implications of this for increasing yield with a minimal sacrifice of earliness, is to search for early flowering materials with a longer PFP.

Efficiency parameters measured included several growth rates, yield/day and harvest index. The early materials showed an advantage principally in Experiment B in Net Assimilation Rate, a measure of growth per unit of leaf area. This, again, was due to excessive LAI of late materials in the second study, which lowered their apparent efficiency. In other parameters measured, early materials were not necessarily superior. Indeed, in yield/day and harvest index early materials were inferior in Experiment A. This is contrary to what is often stated about early genotypes.

One striking observation on crop growth rate was its relative stability from 20 to 40 days. Although LAI increased several fold in this period, net dry weight increase/day increased only 19 to 55%

problems, yield increases of up to 15% were obtained by daily tripping of open flowers (Table 10). Apparently natural pollination is deficient in certain conditions, but the phenomenon is highly variable.

Testing selection criteria for yield potential

There is considerable divergence of opinion on the practicality of increasing yield potential through individual plant selection, particularly utilizing criteria such as harvest index or plant dry weight. To test the effectiveness of such strategies, individual selections were performed in six F_2 populations of small, cream and black seeded parents. Table 11 presents seed yields of resulting F_4 progenies. Visual selection alone produced no improvement over random selection in the F_2, and harvest index also appeared ineffective as a criterion. In contrast, combined measurements of plant dry weight and yield per day resulted in increases over random selection in 5 out of 6 crosses, the one failure occurring where only a single plant showing both high dry weight and yield per day was obtained. These results demonstrated that individual selection in F_2 is a promising technique if quantitative criteria are used.

Table 2. Yield response to split applications of nitrogen (as urea) applied weekly as 10 or 20 kg/ha N soil drenches starting 30 days after planting. Data are means of lines BAT 881 and A 83.

Row spacing (m)	Nitrogen applied (kg/ha)		
	0	10	20
	---------------kg/ha---------------		
0.3	2450	2280	2220
0.6	2070	2230	2230

Level of significance of effect:

Distance	NS
Nitrogen	NS
Distance x Nitrogen	0.001

Table 4. Correlations among seed weight, cell size in various bean tissues, primary leaf area, and principal components estimated from tissue cell sizes. Data are for 15 accessions including two of subsp. aborigineus.

	Seed weight	Pollen	Root endodermis	Hypocotyl endodermis	Guard cell	Pallis. meso.
Pollen	.71**					
Root endodermis	.81**	.64**				
Hypocotyl endodermis	.18	.33	.36			
Guard cell	.67**	.29	.28	-.35		
Pallisade mesophyll	-.65*	-.69**	-.66*	-.59*	-.08	
Primary leaf area	.88**	.84**	.78**	.29	.38	-.78**
1st principal component	-.91**	-.48	-.50	-.25	-.25	.46
2nd principal component	.28	.00	-.05	-.61*	-.63*	.32

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

Table 6. Growth and efficiency parameters for 16 genotypes representing a range of days to maturity. Experiment A.

Genotype	DF	DPM	PFP	PLT/	PODS/ PLT	SEED/ POD	G/ 100 s	HI	YIELD	YIELD/ DAY	CGR 20 d	CGR 30 d	CGR 40 d	NAR 30 d
	days	days	days	m^{-2}				%	kg/ha^{-1}	$kg/ha^{-1}d^{-1}$	$gm^{-2}d^{-1}$	$gm^{-2}d^{-1}$	$gm^{-2}d^{-1}$	$gm^{-2}d^{-1}$
G 3017	29.2	57.3	28.2	13.9	10.3	3.88	16.3	58	872	15.5	4.61	4.85	2.58	3.95
Pata de Zope	30.5	57.5	26.9	12.8	8.3	3.72	15.8	53	510	9.1	3.95	4.95	3.22	4.61
Rabia de Gato	31.4	60.3	28.9	14.1	11.1	4.20	17.7	56	990	16.2	5.92	7.49	4.93	4.99
Huetar	33.8	60.4	26.6	14.5	9.0	4.18	15.2	41	723	11.8	4.25	4.61	2.93	3.65
G 2858	31.8	62.9	31.1	13.3	8.8	2.92	30.0	55	864	13.7	5.64	6.63	5.23	4.36
XAN 145	37.7	63.2	26.5	14.4	10.1	3.73	14.8	56	983	15.6	5.55	6.87	4.48	4.58
Desarrural	33.5	63.9	30.4	13.5	7.6	3.62	21.5	53	848	13.2	5.14	5.62	4.57	3.13
Rojo de Seda	38.0	64.3	26.3	11.8	10.9	3.57	23.3	54	901	14.1	6.34	8.56	6.27	4.46
XAN 112	36.1	65.2	29.1	12.2	10.4	3.59	17.5	51	750	11.6	4.65	6.05	4.69	5.11
Rojo Nacional	37.2	64.9	27.7	12.1	9.6	3.48	16.0	55	679	10.5	4.05	4.56	3.39	3.34
BAT 41	35.6	64.5	28.8	13.6	8.1	3.70	13.8	49	823	12.8	4.77	5.60	4.19	3.65
JU 84-7	36.3	66.2	29.9	13.5	15.0	4.80	17.3	57	1555	23.3	4.99	7.96	8.47	5.20
BAT 304	35.9	68.1	32.2	15.0	15.1	5.07	17.8	61	1887	27.7	6.76	9.99	9.03	5.53
Negro Huast. 81	39.2	70.0	30.9	14.7	11.7	4.91	17.8	54	1315	18.9	4.80	6.92	6.19	5.06
ICTA-Quetzal	39.5	72.7	33.1	12.8	11.4	4.51	14.2	50	941	12.8	5.58	8.58	7.95	5.21
A 321	38.2	73.9	35.7	15.4	11.8	4.37	32.9	62	2445	33.1	6.23	9.14	9.68	4.01
$\overline{X}$	35.2	64.7	29.5	13.6	10.6	4.02	18.9	54	1068	16.2	5.20	6.77	5.49	4.43
D.E.	3.2	4.8	2.6	1.1	2.2	0.59	5.5	5	503	6.6	0.84	1.72	2.24	0.74
Corr. with seed weight											0.49	0.37	0.42	

Table 8. Correlations of growth and efficiency parameters with days to physiological maturity and yield in two planting seasons.

Character	Experiment A DPM	Experiment A Yield	Experiment B DPM	Experiment B Yield
	days	kg/ha	days	kg/ha
Maximum total dry weight (g/m^2)	0.79***+	0.87***	0.66**	0.87***
	0.60*	0.81**	0.11	0.81**
Leaf area duration	0.86***	0.83***	0.87***	0.72**
	0.76**	0.62*	0.69*	0.41
Total nodes at maturity (n/m^2)	0.55**	0.21	0.43	0.21
	0.59*	0.07	0.47	0.05
Maximum stem length (cm)	0.68**	0.83***	0.68**	0.81***
	0.74**	0.59*	0.50	0.65*
Maximum height (cm)	0.52*	0.35	0.47	0.29
	0.15	0.40	0.05	-0.12
Maximum total leaf area (m^2/m^2)	0.79***	0.78***	0.79***	0.64**
	0.54	0.51	0.59*	0.42
Yield/day (kg/ha/day)	0.58*		-0.03	
	0.28		-0.48	
Harvest Index (%)	0.25	0.64**	-0.29	0.19
	0.05	0.40	-0.28	0.39
Crop growth rate (g/m^2/day)++	0.67**	0.75***	-0.34	0.21
	0.42	0.68*	-0.31	0.57
Net assimilation rate (g/m^2/day)	0.28	0.30	-0.71**	-0.19
	0.04	0.44	-0.56	0.40
Relative crop growth rate (g/g/day)	0.61*	0.50*	-0.27	0.18
	0.31	0.60*	-0.23	0.65*
Grain fill period (days)		0.74**		0.61*
		0.35		0.12

*, **, *** significant at p = 0.05, 0.01 and 0.001 levels, respectively.
+ Upper data represent correlations based on all 16 genotypes. Lower data represent correlations on 12 genotypes, eliminating the 4 considered to be late maturing.
++ Rates at 30 days after emergence.

Table 10. Response of yield in four bean genotypes subjected to artificial tripping of flowers during first 10 days of flowering.

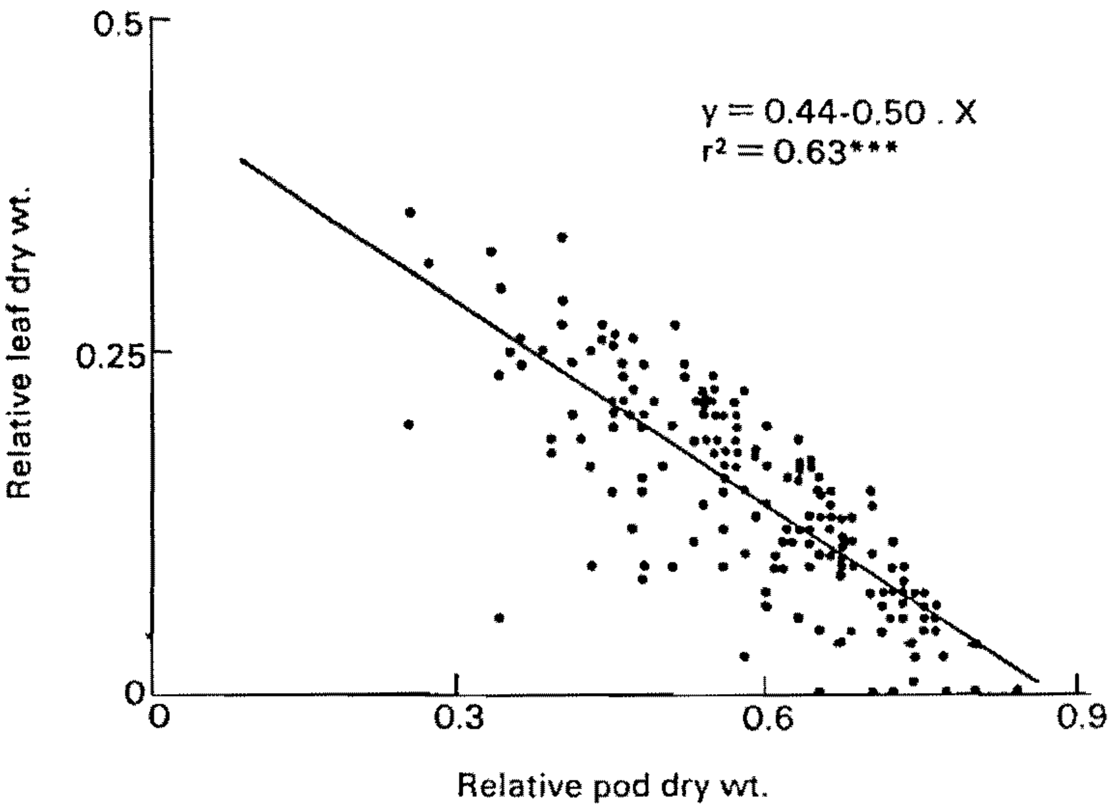
Genotype	Yield		No. of seed	
	Control	Tripped	Control	Tripped
	-------kg/ha---------		---------m^{-2}---------	
BAT 477	2430	2450	1150	1370
BAT 1481	2510	2890	1500	1590
Diacol Calima	1360	1570	240	270
G 1540	1400	1390	580	600
Significance of effect of:				
Treatment	.01		.05[a]	
Line x Treatment	NS		NS	

[a] Calculated for logarithm of seed number.

Table 11. Average seed yields (g/plot) in F_4 progenies from F_2 individual selections based on different selection criteria. HI = Harvest Index; DW = Plant Dry Weight; Y/D = Yield per Day; Vis. = Visual Assessment.

	Selection Criteria									Parental yields	
	1	2	3		Visual selection plus				Random		
Cross	HI	DW	Y/D	Vis.	1+2	1+3	2+3	1+2+3	(F_2)	Female	Male
A 429 x XAN 112	266 (20)	312 (10)	283 (3)	270 (62)	-	-	287 (13)	-	258 (55)	268	256
A 429 x Chichicaste	238 (8)	371 (1)	-	248 (20)	292 (1)	-	319 (4)	291 (4)	234 (58)	268	253
A 429 x Pata de Zope	258 (16)	286 (9)	-	269 (23)	-	258 (2)	317 (4)	-	264 (54)	268	259
DOR 41 x Aguascal. 92	250 (3)	-	-	247 (10)	-	247 (1)	221 (1)	292 (2)	245 (56)	399	201
A 429 x Pecho Amarillo	253 (21)	253 (9)	-	263 (128)	-	-	282 (9)	-	257 (55)	268	258
A 429 x DOR 44	237 (22)	-	263 (10)	262 (63)	-	-	273 (5)	326 (1)	254 (56)	268	355

Figure 1. Relation between leaf and pod dry weights of plants of G 4523 expressed relative to total plant dry weight. Variation in pod set induced by depodding treatments at three dates.



5. Photoperiod-Temperature Adaptation

Routine screening

Evaluation of photoperiod response of flowering screening has continued at Palmira, using artificial 18 hour daylengths to delay flowering (see 1977 CIAT Annual Report). Approximately 600 germplasm accessions were evaluated in 1986 as part of continuing efforts to characterize responses of germplasm in different bean production regions. In response to interest in the use of interspecific crosses to introduce desirable characteristics into Phaseolus vulgaris, 70 accessions of three other Phaseolus species were also evaluated. P. acutifolius and P. coccineus were notable for their high levels of sensitivity (Table 1), suggesting that sensitivity is a common ancestral trait. Work with interspecific crosses should anticipate problems with photoperiod sensitivity.

Long day response of flowering

The typical short day response of bean cultivars makes it difficult to exploit delayed maturity as a route to higher yields under tropical conditions. However, a few studies have suggested possible long day responses in certain cultivars. With such a response, the short daylengths of tropical areas should delay flowering, thus causing later maturity. Comparison of five black seeded indeterminate lines selected for diverse reaction to photoperiod suggested a long day response for 11 vs 15 hour treatments (Table 2). Although delays were only of three to six days, this is sufficient to increase yield significantly. However, attempts to further demonstrate a long day response using the conventional screening system failed. In evaluating over 20 materials which had previously shown hastened flowering under the 18 hour treatment, not one material showed this response in this year's evaluations. Apparently, occasional field evaluations suggesting a long day response simply reflect measurement error inherent in the screening system.

Short day effects on stem elongation

Although bred lines perform well in monoculture in Central America, there is evidence that some lines are less well adapted to second semester relay cropping with maize. A possible explanation is that bred materials lack a short day response for stem elongation or climbing ability. Testing this, five black seeded indeterminate cultivars were grown under 11 and 15 hour daylengths, and stem elongation was measured at 29 days. G 2997 and DOR 44, materials which perform well in relay, showed the greatest difference in elongation (Table 3). A subsequent trial of 11 hours light with or without a 0.5 hour red light treatment as a night break resulted in similar responses, suggesting that the response is phytochrome regulated.

Table 1. Photoperiod response of flowering in *P. acutifolius*, *P. coccineus*, and *P. lunatus*.

	Number of entries with response of:								
	1[a]	2	3	4	5	6	7	8	Total
P. acutifolius	0	0	1	0	0	1	0	18	20
P. coccineus	0	0	0	0	0	1	0	29	30
P. lunatus	7	2	0	0	0	1	0	10	20

[a] Photoperiod response class where 1 = 0 to 3 delay in flowering under 18 hour daylength, 2 = 4-9 day, 3 = 10-19.... 8 = no flowering at 100 days after planting.

Table 2. Days to flower under 11 and 16 hour daylengths in growth chamber.

	11 hours	15 hours	Delay
	-----------------days-----------------		
G 5474	44.0	40.5	-3.5
JU 80-11	47.0	41.7	-6.3
G 2997	33.8	33.8	0.0
G 17650	40.3	45.0	4.7
DOR 44	43.8	40.3	-3.5

Analysis of Variance:

	F
Daylength	0.74
Cultivars	4.32
Interaction	15.41**

** Significant at p = 0.01 level.

Table 3. Stem length of five 29 day old cultivars under two daylengths.

Cultivar	11 hour	15 hour	Length Change	
	----------------cm----------------			-%-
G 17650	112.3a*	105.2a	-7.1	-7
G 2997	87.8 b	57.0 b	-30.8	-54
DOR 44	63.3 c	46.2 b	-17.1	-37
G 5474	40.2 d	46.7 b	+6.5	+14
JU 80-11	32.2 d	26.5 b	-5.8	-22

* Values followed by the same letter within a column do not differ at the p = .05 by Duncan's test.

Inducing flowering in Andean cultivars

Use of Andean germplasm in breeding programs has been hindered by failure of some accessions to flower in environments with higher temperatures or long photoperiods. Studies of photoperiod response suggested that flowering might be induced at CIAT Palmira (24°C mean temperature) by use of very short photoperiods. This was borne out in a comparison of flowering in five bean cultivars. In the control conditions consisting of natural daylengths and ambient temperature, E 605 and cv. Mortiño did not flower, but with a six hour daylength (achieved by moving pots between a darkened room and an open air patio), they flowered in 41 and 40 days respectively (Table 4). Pod set was adequate as compared to the other cultivars, suggesting that possible problems of pollen infertility or other adverse affects of warmer temperatures were unimportant. A subsequent experiment has shown that two weeks of short day treatment resulted in flower bud formation, but the buds failed to develop further. The technique should also work for multiplication of photoperiod sensitive materials under quarantine conditions in warm sites.

Table 4. Flowering and pod set of five bean cultivars under natural and six hour day lengths at CIAT Palmira.

	Cultivar				
Treatment	Diacol Calima	ICA Tundama	E 605	Diacol Andino	Mortiño
Days to flower:					
Control	29	42	0	37	0
6 hour daylength	27	36	41	31	40
Pods per plant:					
Control	14	10	0	13	0
6 hour daylength	12	16	13	14	9

6. Drought Tolerance

Screening for drought tolerance

During 1986 emphasis was given to yield testing promising germplasm and the first materials bred at CIAT specifically for drought tolerance. Preliminary screening was performed under mild stress in the first semester, while exceptionally dry weather (less than 30 mm of rainfall from establishment to mid-pod fill at both Palmira and Quilichao) permitted evaluation under high levels of stress in the second semester.

In Stage I screening (156 materials), the most striking result was the outstanding performance of three *P. acutifolius* lines supplied by the University of California at Davis (Table 1). The fact that they gave the highest yields at both sites was a clear demonstration of their drought tolerance. Part of their superiority is undoubtedly due to their extreme early maturity under drought. There remains the question of whether their very small seed size (less than 0.1 g) is somehow related to drought tolerance. Given known correlations between seed size and cell size, and cell size and drought tolerance, it is not unlikely that some portion of the tolerance of *acutifolius* materials would be lost if incorporated into materials with large seeds.

Several materials bred for drought tolerance outperformed the tolerant checks BAT 477 and G 17722 in one of the two sites, but only TY 3331-I was superior at both sites. This is consistent with previous impressions that while conventional yield breeding will permit incorporation of existing levels of tolerance into different genetic backgrounds, achieving increased levels of tolerance will prove very challenging.

Stage 2 screening (72 lines) indicated that RAB 141 and G 2447 were particularly promising (Table 2). Attempts to identify large seeded materials with good tolerance were not successful, and the problem of identifying materials with outstanding tolerance at both sites was also obvious.

Materials from Stage II screening will be used to form a new international drought yield trial. However, given the importance of local adaptation noted in the previous international trials, it is expected that national programs will place greatest emphasis on developing strategies for selecting for tolerance under their local conditions.

Drought tolerance mechanisms

Given the importance of local adaptation in determining levels of drought tolerance, increased importance has been given to aiding national programs in investigations of tolerance mechanisms. Trials were visited near Goiania, Brazil (CNPAF) and Durango, Mexico (INIFAP). Basic patterns of response of leaf water potential, stomatal conductance and canopy temperature in Brazil were similar to those seen at CIAT stations, with stressed plants showing a large (-1.0 MPa) mid-day depression in water potential, accompanied by elevated stomatal resistance and canopy temperatures. In contrast, under the conditions in Durango, stressed plants showed only a -0.1 to -0.1 MPa drop in potential, while non-stressed plants reached -0.6 MPa. Stomatal resistance and canopy temperature in drought plots exceeded non-stressed plots. Apparently cultivars adapted to the Durango area follow an extreme strategy of water conservation at the cost of minimizing photosynthesis.

The surprising performance of the three _P. acutifolius_ lines in routine screening emphasized the importance of understanding the value of earliness in drought screening. Data for days to flower and maturity were analyzed for screening trials from 1983 onward (Table 3). Although earliness was advantageous in the majority of the trials, strength and direction of correlations varied greatly.

Table 1. Best entries at Palmira and Quilichao in Stage I screening (156 lines) for drought tolerance.

Line	Seed size	Palmira Yield	Palmira Matur.	Quilichao Yield	Quilichao Matur.	Geometric mean
		kg/ha	days	kg/ha	days	kg/ha
Best in Palmira:						
L172	S	2070	61	890	67	1360
L174	S	1760	62	760	66	1160
L169	S	1460	66	840	67	1110
TY 3388-8	S	1100	80	120	77	360
TY 3331-1	M	1060	75	760	70	900
BF 2570-1	M	1010	84	270	76	520
MX 3020-1	S	990	76	100	69	310
BAT 477	S	980	78	295	72	540
TY 3424-4	S	970	74	250	70	490
FEB 4	S	960	79	280	75	520
Pirata	M	950	85	370	75	590
TY 3355-1	L	910	80	430	70	630
Best in Quilichao:						
L172	S	2070	61	890	67	1360
L174	S	1760	62	760	66	1160
L169	S	1460	66	840	67	1110
TY 3331-1	M	1060	75	760	70	900
TY 3355-3	S	440	83	570	73	500
TY 3424-3	S	690	76	540	70	610
TY 3355-2	S	910	80	530	71	690
TY 3355-5	S	590	80	530	70	560
MITAL 226	S	390	82	530	75	450
PVA 957	L	300	74	520	70	390
MX 3004-8	S	570	74	520	71	540
TY 3419-10	S	300	78	520	69	390
Bico de Ouro	S	280	79	510	70	380
Tolerant Checks:						
BAT 477	S	980	78	295	72	540
G 17722	M	640	82	203	74	360
Mean		440	80	240	73	

Table 2. Best entries at Palmira and Quilichao in Stage II screening for drought tolerance.

Line	Seed size	Palmira		Quilichao		Geometric mean
		Yield	Matur.	Yield	Matur.	
		kg/ha	days	kg/ha	days	kg/ha
Best in Palmira:						
A 114	S	1240	87	100	75	350
G 5070	S	1050	83	310	76	570
RAB 141	S	1934	75	500	82	720
G 17722	M	990	84	270	72	520
G 2447	S	990	81	550	72	740
BAT 85	S	950	80	320	72	550
G 1197	S	950	82	360	73	550
BAT 477	S	950	79	390	73	610
G 259	S	920	83	260	76	490
		0				
Best in Quilichao:						
G 110	S	340	83	630	72	460
A 97	S	320	82	560	73	420
G 5215	S	630	77	550	74	590
VABRA 386	S	230	80	540	72	350
VABRA 379	S	470	84	530	75	500
BAT 1289	S	370	81	520	72	440
FEB 15	S	290	82	500	73	380
A 195	S	490	75	480	70	480
		0				
		0				
Tolerant Checks:						
BAT 477	S	950	79	390	73	610
G 17722	M	990	84	270	72	520
Mean		510	82	320	74	
L.S.D.		330	4	140	3	

Table 3. Effectiveness of earliness as a source of drought tolerance as judged by correlations between yield and days to flower or maturity.

Trial	Site	Mean yield	No. of entries	Correl. with yield Flower	Correl. with yield Maturity
8427	Palmira	1650	72	-.21	-.39**
8450	Palmira	1320	144	-.20*	-.22*
8446	Palmira	1080	72	-.04	-.18
8447	Quilichao	820	72	.22	-.17
8520	Palmira	600	72	.17	.30**
8521	Quilichao	2200	72	.40**	.08
8535	Palmira	2160	240	.14	-.24*
8536	Quilichao	2440	240	.21*	.29**
8618	Palmira	440	156	-.38**	-.51**
8619	Quilichao	240	156	-.38**	-.53**
8620	Palmira	510	72	-.03	-.11
8621	Quilichao	320	72	-.42**	-.34**

*,** Significant at the p=0.5 and p=0.1 levels respectively.

7. Tolerance to Acid Soils

During 1986, screening of advanced lines for efficiency at low levels of P and for tolerance to high levels of Al saturation (over 50%) were continued. A review of data from eight years of screening indicates genetic variability of beans for these two characteristics is low, thus explaining difficulties in obtaining lines outstanding for these characters. Furthermore, the data suggest that efficiency and tolerance are determined by separate mechanisms.

The principal group screened in 1986 was comprised of small black and red seeded materials of growth habit types II and III which were adapted to Central America and the Caribbean. In addition, lines having growth habit types II and III from the 1984 and 1985 EPs were evaluated.

Screening consisted of the following treatments:

1. No stress - 120 kg/ha of P as Triple Superphosphate and 2 tons/ha dolomitic lime.

2. P stress - 12 kg/ha of P as Triple Superphosphate and 1 ton/ha dolomitic lime.

3. Al stress - 60 kg/ha of P as Triple Superphosphate and no dolomitic lime (soil analyses indicated that residual effects of previous applications of lime were sufficient to maintain Al saturation near 50% at the onset of the experiment).

Applications of nitrogen, potassium, sulphur, boron and zinc were provided at levels sufficient to assure they were not limiting factors during the experiment. Standard checks used were the Brazilian cultivars Rio Tibagi (growth habit II) and Carioca (growth habit III).

Tables 1 and 2 present materials outstanding for P efficiency of growth habits II and III, respectively, while Tables 3 and 4 present similar data for materials with tolerance for high Al saturation.

In studies of mechanisms of efficiency at low levels of P, uptake with time and the development of the yield components were measured under P stress conditions. Yield under the no stress conditions showed little variability, indicating a similar yield potential in all the varieties tested. However, yield under P stress showed a several fold difference between the last and most efficient varieties (Table 5).

An analysis of the P uptake pattern and its effect of grain yield was done using the Path Analysis technique. Use of this technique determined the periods of P uptake which were most important in the determination of grain yield. The data was divided into two groups; those varieties which yielded poorly under P stress but were very responsive to P fertilization; and those varieties which yielded well under P stress but were not as responsive to P fertilization. The Path Coefficients (Table 6) show the relative importance of each period of uptake (i.e. if one coefficient is twice as large as another, variability in P uptake during that period has twice as much impact on yield). The results indicate that, in the P responsive varieties, the period from 15-30 days after germination was very important in P uptake (a period of rapid vegetative growth) while in the efficient non-responsive varieties this period was less important. Also, under P stress conditions the P efficient varieties tended to lag behind the inefficient varieties in dry matter accumulation (Table 7), indicating that P uptake had little to do with P efficiency under low availability conditions.

An analysis of which yield components were most responsible for the variability in the observed grain yields was also undertaken. In both the P efficient and P responsive types, the number of pods per plant was most important followed by the number of seeds per pod, and least important was the weight of the individual grains (Tables 8, 9).

P uptake was not greatly different between the efficient and inefficient varieties; in fact, the efficient varieties were somewhat slower in uptake during the first few weeks. The differences between the efficient and inefficient varieties consisted primarily of how the plant utilized the P it had. In particular, the plant's ability to set pods and seeds under P stress is important. Future studies should concentrate on P dynamics within the plant during flowering and the associated morphological changes.

A study of root growth under P stress and drought stress showed no differences in root length between Carioca and ICA Pijao at any growth stage (Table 10). This suggests that root length is not a useful characteristic for selection for efficiency under low P. This contrasts with the situation for high Al saturation where previous studies at Popayan (see CIAT's Annual Report for 1985) showed that the lines with the greatest tolerance to high levels of Al were those which achieved greatest root length.

Table 1. Mean yields of lines of growth habit II showing outstanding performance at low P levels (12 kg/ha).

Habit II Lines	No stress	With P stress
	kg/ha	
BAT 1467	3228	1205
XAN 78	3153	1275
XAN 198	3372	1149
G 4454	2923	1204
NAG 1	3458	1339
BAT 1432	3066	1574
NAG 183	3715	1176
NAG 160	3176	1191
A 283	3182	1105
NAG 161	3464	1203
NAG 39	3354	1176
NAG 200	2968	1158
NAG 199	3470	1376
Rio Tibagi (check)	2806	1003
CV(%)	8.7	36

Table 2. Mean yields of lines of growth habit III showing out - standing performance at low P levels (12 kg/ha).

Habit III Lines	No stress	With P stress
	kg/ha	
BAT 271	2979	1409
RAB 404	2867	1359
RAB 379	2061	1046
NAG 177	3224	1236
NAG 195	2828	1257
G 11893	2392	1204
Carioca (check)	3024	965
CV (%)	11.9	25

Table 3. Mean yields of lines of growth habit II showing outstanding performance under high Al saturation (50%).

Habit II Lines	No stress	With Al stress
	kg/ha	
NAG 202	3012	1405
BAT 1658	3050	1225
BAT 1647	3395	1614
NAG 199	3470	1379
BAT 1467	3228	1422
RAB 411	2469	1209
G 4000	2713	1435
NAG 200	2968	1446
NAG 51	3387	1426
G 4454	2923	1373
NAG 13	3421	1263
NAG 11	3733	1839
NAG 160	3176	1537
NAG 171	3081	1331
NAG 184	3017	1228
NAG 176	2767	1258
RAB 381	3025	1274
BAT 1432	3066	1206
NAG 204	3028	1331
G 4495	3029	1413
NAG 201	3044	1688
XAN 78	3153	1350
RAB 353	3110	1292
XAN 151	3501	1523
NAG 203	3185	1331
NAG 170	2969	1225
DOR 227	3198	1464
NAG 45	3137	1681
NAG 163	3230	1361
BAT 58	2769	1351
NAG 198	3198	1214
Rio Tibagi (check)	2806	1023
CV (%)	8.7	30.1

Table 4. Mean yields of lines of growth habit III showing outstanding performance under high Al saturation (50%).

Habit III Lines	No stress	With Al stress
	kg/ha	
FEB 17	3194	602
RAB 379	2061	444
DOR 344	2392	415
RAB 429	2501	434
DOR 342	1890	423
RAB 404	2867	503
RAB 367	2034	409
RAO 48	2572	485
RAB 440	2471	446
NAG 195	2828	541
BAT 271	2979	400
RABA 234	2472	452
RIZ 34	2329	401
RAB 441	2991	503
RAO 33	2368	491
RAB 388	2064	437
G 18244	2031	465
BAT 304	2165	477
RAO 34	3167	478
Carioca (check)	3024	180
CV (%)	11.9	49

Table 5. Yields (kg/ha) of the best varieties under P stress in a screening trial in Popayan.

Growth Habit II (36 varieties)	
LINE	YIELD
ICA Pijao	3983
RAO 30	3531
RIZ 45	3219
RAB 211	3192
NAG 27	3076
RAB 201	2983
Trial mean	2445
Growth Habit II (16 varieties)	
LINE	YIELD
997-CH-73	4242
Carioca	4208
DOR 342	3811
RIZ 42	3704
Trial Mean	3088

Table 6. Relative importance of the period of P uptake under P stress on the development of yield (path coefficients).

Period (Days)	Efficient Lines	Inefficient Lines
0-14	.31	.36
15-30	.38	.58
31-48	.04	.20

Table 7. Plant growth and P absorption during the first 14 days after germination.

	Efficient Lines	Inefficient Lines
Leaf Weight (g)	15.3	18.5
Stem Weight (g)	9.5	11.5
Total P (g)	0.115	0.142

Table 8. Relative importance of the various yield components in determining yield under P stress conditions (path coefficients).

	Efficient Lines	Inefficient Lines
Pods/plant	.68	.69
Grains/Pod	.43	.57
Grain Weight	.25	.29

Table 9. Effect of P stress (12 kg/ha of P) on number of pods per plant in four bean cultivars, measured in two semesters.

Line	Season A	Season B
Carioca	10.2*	9.3[a]
G 4000	8.0[bc]	8.4[ab]
Puebla 152	9.1[ab]	8.8[a]
ICA Pijao	6.6[c]	6.8[b]

* Means with the same letter in the same column are not significantly different at P = 0.05 level with Duncan's multiple range test.

Table 10. Effect of P stress (12 kg/ha of P) on root length during different growth stages, and in two trials with contrasting water regimes.

Root Length	Growth Stage	Trial 1a		Trial 2a	
		Carioca	ICA Pijao	Carioca	ICA Pijao
Primary	20 days	10.1[a]*	10.2[a]	12.4[a]	14.1[a]
	Flowering	18.2[a]	17.7[a]	13.9[a]	14.4[a]
	Physiol. maturity	15.1[a]	17.2[b]	16.1[a]	17.8[a]
Secondary	20 days	18.7[a]	17.8[ab]	18.4[a]	19.1[a]
	Flowering	29.1[a]	30.2[a]	20.6[a]	22.0[a]
	Physiol. maturity	20.8[b]	23.7[ab]	21.8[a]	24.3[a]

* Means with the same letter in the same column are not significantly different at P = 0.05 level with Duncan's multiple range test.

a. Trial 1 with normal moisture regime (457 mm water during growth cycle), and Trial 2 with drought stress (200 mm water).

8. N-Fixation

Breeding for enhanced nitrogen fixation

The breeding program for improving nitrogen fixation in small seeded Central American materials continued with minor changes in the evaluation methods and selection criteria. Preliminary evaluations were made of some materials with importance or promise for Africa, and an inbred-backcross breeding program was initiated.

F_1 and F_2 materials from 60 crosses made between RIZ lines and promising materials for Central America and the Caribbean, were advanced in CIAT-Palmira without selection. Three hundred single plant selections from F_3 populations were progeny-tested in Palmira and Popayan in 1986 A. Selections were made on the basis of grain type, vegetative vigor and pod load, when grown under mild N stress. Elite, uniform materials (F_4 and F_5) were evaluated in replicated yield trials in Popayan and Santander in 1985 B and in CIAT-Palmira in 1986 A. The selection criteria comprised early and mid-flowering nodulation scores, vigor, grain type and yield.

Although some advances have been noted in better grain type (especially among red and white seeded materials), and disease resistance; improvements in nodulation characteristics and yield under low N have been marginal in the past two years. Two probable reasons for this are: a) that some parents have been included with little prior knowledge of their nitrogen fixation characteristics; and, b) there was low selection pressure for good fixation. The good growth of maize and non-nodulating soybeans in Santander and Palmira and the marginal response to N fertilizer in Popayan, verify the high mineralization rates at the three stations. Although precropping with maize or wheat lowers the initial mineral N levels, this is not sufficient for high selection pressure. In field trials this season the beans are being intercropped with wheat in Popayan and maize in Palmira in an attempt to increase selection pressure. Materials that enter the EP are being evaluated for nodulation patterns and yield under low and high N to identify a wider range of materials with good fixation, as well as to aid in the selection of better parents.

In the breeding program for enhanced nitrogen fixation, emphasis has focused on small seeded indeterminate beans. However, at the beginning of this year it was decided that some priority should be given to materials for Africa, including larger seeded determinate and indeterminate bush types.

Nodulation patterns of 20 materials, with some importance or promise for specific regions in Africa, were evaluated in Popayan 1986 A to help define breeding strategies for increasing fixation in these materials (Figure 1). Some lines such as Canadian Wonder, Catrachita and RIZ 30, demonstrated good early nodulation, but by mid-flowering the nodules were already starting to senesce. Other lines such as Ancash 66 and Tostado were excellent later in the growth cycle. Poor nodulating materials included Mutiki 2, Rubona 5, XAN 112, Natal Sugar and Kabanima. It was interesting to note that growth habit appeared to have little relation to nodulation potential: one of the best lines was a determinate type I, while one of the others was a type IIIB. In a number of comparisons between varieties in Rwanda, Tostado was well nodulated while Rubona 5 and Mutiki 2 had few nodules, results which support the data from Popayan.

A backcross program was initiated to incorporate early nodulation from CIAT line RIZ 29 into African cultivar Mutiki 2. The objective was to see whether this component of N_2-fixation could be readily incorporated, and whether this would result in improved overall performance. Mutiki 2 is a large seeded, growth habit I cultivar from Uganda, which has been found to nodulate poorly both in Rwanda and Popayan, but is otherwise a promising cultivar. Roots of seedlings that had been inoculated with Rhizobium strains CIAT 166, 632 and 899, were examined fifteen days after planting in sand. RIZ 29 had already developed large red nodules, whereas Mutiki 2 had small white nodules. The simple cross of Mutiki 2 x RIZ29 segregated a total of 22 poor; 55 medium; and 23 well nodulated plants. The first backcross to Mutiki 2 segregated a total of 38 poor; 37 medium; and 19 well nodulated plants, suggesting that this character is quantitatively inherited. Well nodulated plants were transplanted and backcrossed again to Mutiki 2. The second backcross will be screened in the same way and lines combining the chracteristics of Mutiki with early nodulation will be multiplied for field evaluations. Although only a single component of N_2-fixation, this character has the advantage of being very simple to select.

Nodulation mutants

In order to improve the efficiency of ^{15}N evaluations of nitrogen fixation, it is important to identify non-fixing controls that are as similar as possible to the material to be tested. In a number of legumes, non-nodulating mutants have been identified, but they were not available in beans. Such lines would also be valuable for identifying genes involved in nodulation, and for more fundamental physiological studies, all with the ultimate goal of improving nitrogen fixation in beans.

In collaboration with Rothamsted Experimental Station, U.K., investigations into obtaining non-nodulating and super-nodulating bean lines by mutation were carried out. Super-nodulating bean lines are those which continue to nodulate in the presence of nitrate, and which nodulate more than usual under all conditions. Nodule mass is one component which has been identified in beans as contributing to improved fixation.

Mutagen treatments used have been described in Section I. C. (Genetic Variability from Biotechnological Techniques). Second generation (M2) seed of each genotype (RIZ 30 and RIZ 36) was divided into 0 N (-N) and 150 mg/1 KNO_3 (+N) treatments and planted in perlite. Before emergence they were inoculated by watering, with mixture of Rhizobium strains CIAT 632 and CIAT 899. A total of 3360 M2 plants per genotype were screened. The 150 mg/1 KNO_3 concentration was previously determined to suppress nodulation completely in the parental genotypes. Selection was carried out by uprooting the plants three weeks after planting, and selecting those with no nodules in the -N treatment (non-nodulated plants), and those with abundant nodules in the +N treatment (super-nodulated plants). Selected plants were transplanted to soil and grown on to seed.

Seed from the selected plants (M3 generations) was sown in perlite, 2 replications of 3 seeds per line, to confirm the nodulation characteristics. The progeny of non-nodulated plants were evaluated in the absence of nitrate (-N), and the progeny of super-nodulated plants were evaluated in the presence of nitrate (+N). Each tray had a row of the appropriate parental genotype in the center, flanked by 3 rows of M3 lines. The plants were scored for nodulation three weeks after planting on a 1-9 scale (1 = no nodules).

Screening of the M3 generation showed a high drop-out rate of apparent nodulation mutants. Only lines with consistent performance in both replications were selected, although further single plant selections were made in some cases. The following lines were consistently non-nodulated and have since been multiplied for further tests at CIAT: lines 42, 62, 95, 109, 125, 204, 224, and 227. Consistently ineffective nodules were identified in line 101, which has also been multiplied at CIAT. Some of these lines show poor seed set and loss of vigor, and so they have been backcrossed to the parental genotype in order to recuperate the gene responsible for non-nodulation without other abnormalities. The backcrosses will serve at the same time in the investigation of the inheritance of this character.

Results with apparently super-nodulating lines have been inconsistent, and it is not yet possible to say whether such lines have been identified. Further studies with the non-nodulating lines will investigate the causes for non-nodulation, including possible strain specificity or temperature effects. Field trials will be carried out with the mutants identified.

Quantification of N_2 fixation

An experiment using ^{15}N isotope dilution to measure N_2 fixation of different bean genotypes was reported in the Annual Report 1985. The trial was done in the field at CIAT-Palmira in collaboration with Rothamsted. A follow-up experiment was done this year, comparing the same varieties, but carried out in pots in the glasshouse. The purpose was to see if the genotype ranking for fixation was the same in conditions of almost zero mineral N, as it was in the field where fairly high levels of mineral N were present. Results are shown in Table 1. The differences in N_2-fixation between genotypes were similar to those observed in the field. In general, the RIZ lines and A 268 fixed more N than the BAT lines. The only exception was RIZ 30 which was one of the best lines in the ranking for N_2-fixation in the field, but not in the glasshouse.

Table 1. Nitrogen accumulation and nitrogen fixation in genotypes grown for 64 days in the glasshouse in ^{15}N-labelled soil.

Genotype	Shoot N (mg/pot)	Atom % ^{15}N excess	% N fixed	N fixed (mg/pot)
RIZ 29	188	0.030	94	177
RIZ 36	178	0.029	94	167
A 268	178	0.028	94	167
RIZ 27	168	0.025	95	160
BAT 76	168	0.023	95	160
RIZ 30	162	0.033	93	151
BAT 1297	161	0.027	94	151
BAT 1554	150	0.034	93	142
BAT 1432	149	0.032	93	140
BAT 332	146	0.033	93	137
SE	14.7	0.0049	0.9	14.7
Sorghum	10	0.484		
SE	0.4	0.0033		

Rhizobium-legume evaluation on-farm

It is necessary to evaluate the importance of N as a yield-limiting factor in a given target zone. The need and potential for increasing nitrogen fixation through the introduction of better fixing genotypes and/or modification of the Rhizobium population by inoculation must be defined. Local varieties and possible new introductions need to be evaluated for fixation capacity and the effects of inoculation studied. Work conducted in Ipiales, Colombia is an example of this approach.

In Ipiales, work was initiated in 1985 with evaluations of bean nodulation in farmers' fields. The local variety Mortiño and the new release, Frijolica 0-3.2, were well-nodulated but often with a large proportion of ineffective-appearing nodules. The large native *R. phaseoli* population was confirmed with most probable number counts generally in the range of 10^6 to 10^7 *R. phaseoli* per g soil. A yield response by both Frijolica 0-3.2 and Mortiño to inoculation with a mixed strain inoculant was observed in two of three farm trials in 1985

B (Table 2). The lower bean yield as a result of nitrogen fertilization may have been due to increased growth and competition from the maize; unfortunately maize yield data was not available for all the trials. Mortiño consistently formed more nodules than Frijolica 0-3.2 but there was no increase in nodule number in response to inoculation. Strain screening studies were done to see if more effective and competitive strains could be identified.

Thirty strains from the collection were evaluated for their ability to grow at low temperatures. The strain variability in cold tolerance was striking (Table 3). The most cold tolerant of these strains were screened in pots of soil along with 15 new isolates from Ipiales' soils, for their ability to cause a plant growth response in the presence of the native rhizobium population (Figure 2).

Table 2. Effects of N fertilizer and *R. phaseoli* inoculation. Ipiales 1985 B. Maize (M) and bean (B) yield (kg/ha).

			2590 m	2540 m	2700 m		
			A. Pinchao	S. Rosero	J. Chaspuengal		Mean
			Chaguaipe	Contadero	Potosí		bean yield
Variety	Inoc[1]	N[2]	B	B	B	M	B
Frijolica 0-3.2	+	-	755	245	166	3985	388
Frijolica 0-3.2	-	-	501	157	335	3739	331
Frijolica 0-3.2	-	+	393	227	303	4645	307
Mortiño	+	-	306	206	141	3811	218
Mortiño	-	-	138	121	144	3909	134
Mortiño	-	+	127	135	84	4469	115
Mean			370	182	206	4071	249
LSD (10%)			167	96	83	715	68

[1] Mixture of 3 strains (3 g/site).

[2] Equivalent to 50 kg/ha of N.

Table 3. Growth of Rhizobium phaseoli on yeast manitol agar at low temperatures ++: normal growth; +:poor growth; -: very little or no growth

Strain	Temperature °C				Strain	Temperature °C			
	10	15	20	28		10	15	20	28
CIAT 2	+	++	++	++	CIAT 209	+	+	++	++
CIAT 5	+	++	++	++	CIAT 214	-	-	+	++
CIAT 57	-	-	++	++	CIAT 255	-	+	++	++
CIAT 65	-	+	++	++	CIAT 321	+	+	++	++
CIAT 73	-	-	+	++	CIAT 323	+	++	++	++
CIAT 75	-	-	++	++	CIAT 385	-	+	++	++
CIAT 96	-	+	++	++	CIAT 390	-	-	++	++
CIAT 123	-	+	++	++	CIAT 407	-	+	++	++
CIAT 125	+	++	++	++	CIAT 612	+	+	++	++
CIAT 127	-	-	++	++	CIAT 613	+	++	++	++
CIAT 128	+	+	++	++	CIAT 625	-	+	++	++
CIAT 142	+	+	++	++	CIAT 632	-	-	++	++
CIAT 144	+	+	++	++	CIAT 640	-	-	++	++
CIAT 161	-	-	++	++	CIAT 652	-	+	++	++
CIAT 166	+	+	++	++	CIAT 899	-	-	++	++

Inoculation with 21 of the 27 strains resulted in an increase in Frijolica 0.3-2 plant N, with the best strains showing up to 70% of the +N control. A genotype by strain interaction was observed; for example, I-3 and I-8 were two of the best strains with Mortiño. However, some strains were good with both varieties, and I-10, C652 and C5 are being tested as inoculants in trials on-farm this season.

With support from a UNDP grant, teams of agronomists and microbiologists in national legume programs are being trained to carry out the types of studies described for Ipiales. Teams in Costa Rica, Guatemala, El Salvador and Zambia have initiated studies to evaluate the nitrogen fixing symbiosis of local varieties with and without Rhizobium inoculation. Strain screening and selection is being done in local soils, and relative nitrogen fixation potential is to be included as a selection criterion early in the legume evaluation scheme. Methods manuals in Spanish and English have been written to help with this training.

Damage of bean nodules by insect larvae has been observed in many locations however its importance as a factor in limiting fixation has not been determined. A survey of 20 farms in Funes (Nariño, Colombia) (10 with a bean/maize association and 10 sole cropped with beans), was carried out to determine the proportion of damaged (hollowed-out) nodules. Comparisons of with and without maize, were made because of observed increases in damage following maize crops in CIAT-Palmira. Fifteen plants in the early flowering stage were dug up; the number of red/pink nodules counted, the number of hollow nodule shells, and the number of other ineffective-appearing nodules were determined. Damage by insect larvae was obviously an important factor limiting nitrogen fixaton, with up to 60% of the nodules empty (Table 4). There was no effect of cropping system nor bean variety, however.

Table 4. Nodule damage caused by insect larvae on 20 farms. Funes 1985 B.

Bean Variety	With/Without Maize	# nodules on 15 plants	% red/pink nodules	% hollow nodules	% ineffective nodules
Capuli	with	674	80	5	15
Capuli	with	2200	70	10	20
Capuli	with	1500	75	15	10
Capuli	with	575	40	50	10
Capuli	with	1650	70	10	20
Capuli	with	710	50	10	40
Capuli	with	325	40	20	40
Capuli	with	155	40	40	20
Limoneño	with	80	40	40	20
Capuli	with	1200	60	10	30
Capuli	without	455	50	10	40
Capuli	without	1155	70	5	25
Andino	without	547	60	20	20
Capuli	without	2300	50	25	25
Limoneño	without	432	40	30	30
Capuli/Andino	without	260	50	20	30
Capuli	without	34	10	60	30
Capuli	without	100	40	30	30
Capuli	without	60	40	30	30
Limoneño	without	105	60	20	20

Rhizobium strain collection and testing

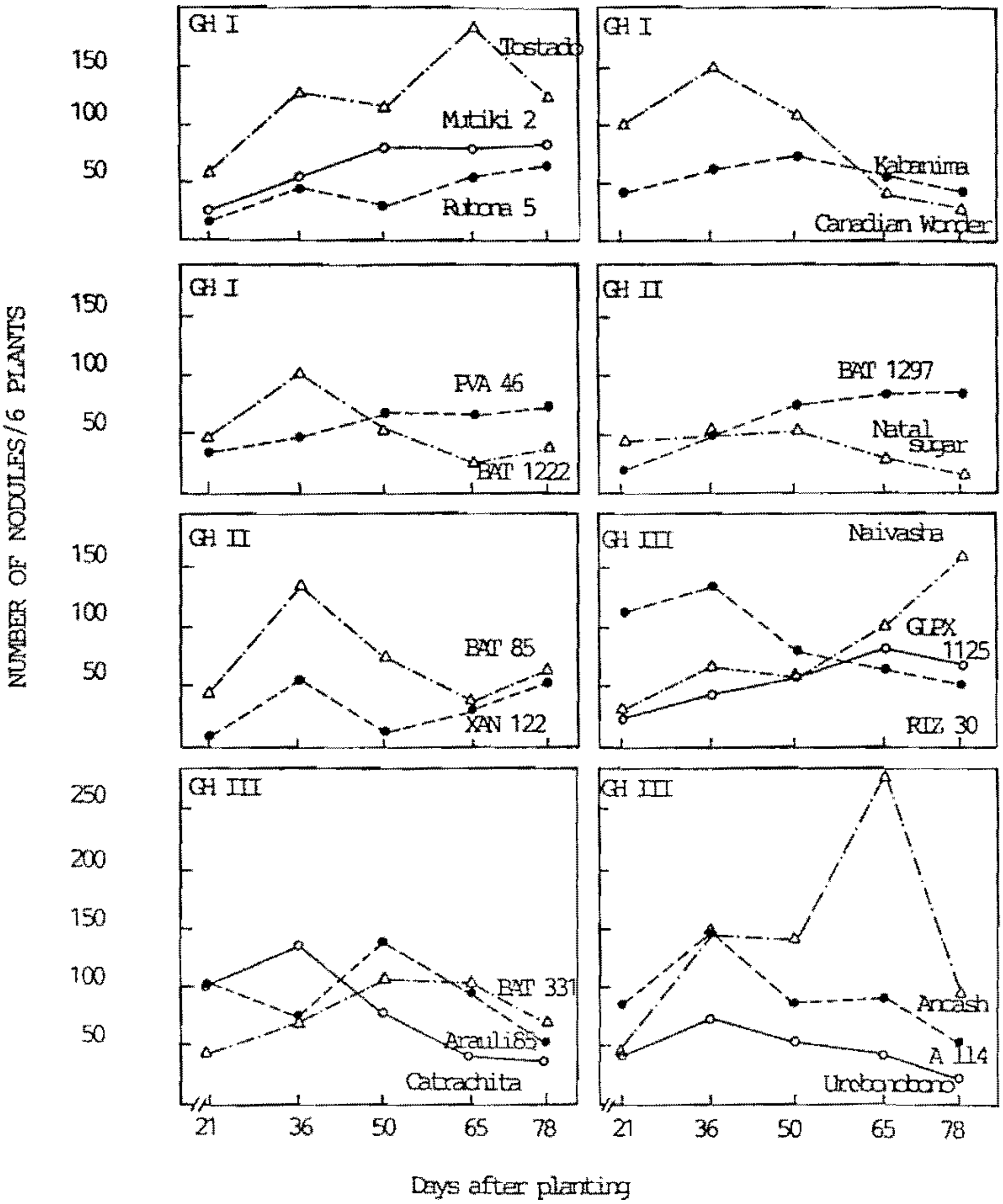
Data demonstrating differences between Rhizobium strains in tolerance and growth at low temperatures is presented in Table 3. In another study, growth at high temperatures was compared. Of 24 of the most important strains in the collection, only 10 were able to grow at 36°C. These were CIAT 2, 5, 45, 166, 214, 323, 348, 640, 652 and 899. It was interesting to note that a number of these (CIAT 2, 5, 166 and 323) were also able to grow at 10°C.

Rhizobium strains were isolated from populations of P. vulgaris subsp. aborigineus in Argentina to widen the genetic base of the collection. Two strains from each of 21 populations were evaluated for their ability to form an effective symbiosis with BAT 76. Thirty-one of the strains were infective, and of these, 26 were also effective resulting in plant growth between 13% and 44% of the plus nitrogen control. Further host range studies are in progress and the best strains will be tested in the routine strain screening experiments.

Some results of the study of native R. phaseoli populations, conducted in collaboration with the Boyce Thompson Institute in Ithaca, New York, are the following. There were no differences in the effectiveness of strains from sites in the Valle (Colombia) where beans had been grown for years, and where beans had never been grown. This was not true for the CIAT-Quilichao sites where strains from previously bean-cropped soil were more effective. Overall strains from Quilichao soils were more effective than those from the Valle and Frijolica 0-3.2 trapped more effective strains than BAT 76. Not surprisingly, more acid tolerant strains were isolated from Quilichao; eight of the 32 strains tested grew at pH 4.6 while none of the Valle strains grew at this pH. Robert and Schmidt at the University of Minnesota defined five R. phaseoli serogroups. Twenty-eight of the Valle strains are in group 2; nine others are not in any of the five groups. Eleven of the Quilichao strains are in group 1, 10 in group 2 and 11 others unreactive. This information will be useful for choosing strains with which to study inoculant survival and strain competition. Some of the strains nodulated legume hosts outside the normal host range for R. phaseoli. These hosts included clover, pea and cowpea. This result is presently being reconfirmed, but if true may explain why R. phaseoli is almost always present in soils where P. vulgaris and P. coccineus have not been grown. Another helpful observation made at BTI is that some R. phaseoli strains are very sensitive to freeze drying. This explains why we have had so much trouble maintaining some strains in the collection and indicates that some stock cultures should be stored using at least two different methods.

The microbiology section of the Bean Program fulfilled requests by sending 185 R. phaseoli cultures to researchers in eight different countries.

Figure 1. Nodulation patterns of some important and promising materials for Africa. Popayan, 1986 A (means of three replications).



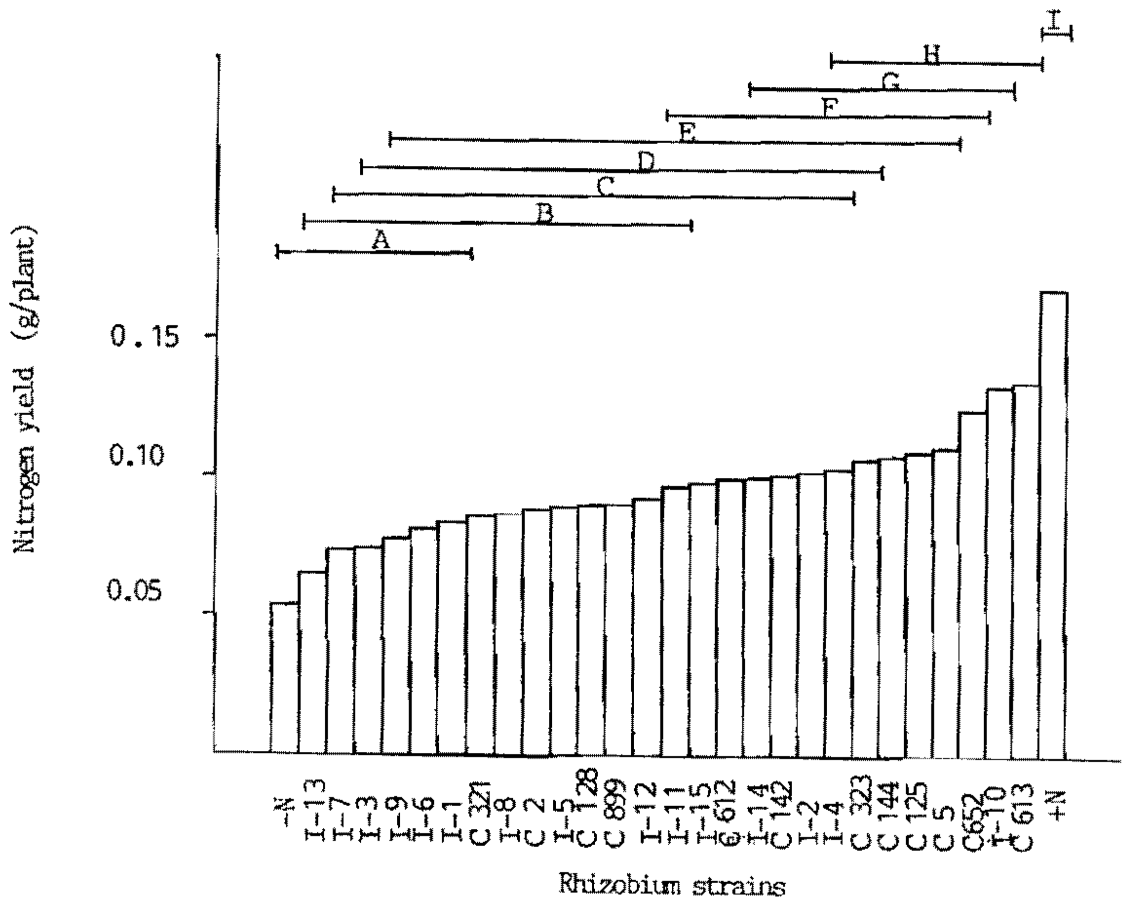


Figure 2. Nitrogen yield of inoculated Frijolica 0-3.2 plants in soil from Ipiales. (Values with the same letter are not significantly different at the 5% level).

9. Nutritional Quality

The principal activities carried out in 1986 in the nutrition and quality laboratory were as follows:

(1) Evaluation of the 1986 EP materials. A statistical analysis of all the parameters of acceptability on all materials evaluated in the laboratory from 1981-1985 was executed;

(2) Execution of a joint project between CIAT and INCAP on methods to measure cooking time;

(3) Studies aimed at identifying the important parameters for water absorption;

(4) Studies on the influence of site, planting time and variety of the cultivar on acceptable nutritional characteristics;

(5) Initiation of a joint project with Italy's National Institute of Nutrition on the toxic factors affecting the digestibility of beans;

(6) Evaluation of a prototype model of a modified Mattson's automatic cooker.

Results of analyses of materials evaluated in the laboratory 1981-1985

A statistic analysis was performed on the following characteristics: crude protein content (1981-1985); average cooking time (TC_{50}) measured using Mattson cookers; percentage of water absorption after 16 hours of soaking, as well as percentage of solids left in the broth. These parameters were studied in conjunction with the following variables: grain color, growth habit, grain size (weight per 100 seeds), and seed coat brilliance (1982-1985).

No significant differences were found for protein content among the majority of the tested varieties (N=1117), but some differences were observed for seed color (Table 1).

Significant differences in average cooking time were related only to seed coat brilliance and grain size. Opaque materials required a shorter cooking time, and large seeded varieties (40 g/100 seeds) required more cooking time. The same variables that were important to percentage of water absorption were important to average cooking time. Materials with high degrees of brilliance absorbed significantly less water and large seeded varieties absorbed significantly more. In regards to percentage of solids in cooking broth, grain color, brilliance, and grain size, were significant (Tables 1, 2 and 3).

Improvement of nutritional and acceptability characteristics

Based on preliminary data on the inheritability of tannins (level of detectable methanol-acidified extract using ultraviolet spectrum), a project was initiated with the objective of improving digestibility from reducing tannins by crossing materials having low levels of these compounds.

For protein level, progeny were selected from materials evaluated in the laboratory that were outside the standard deviation distribution (e.g. materials having a dry base protein content of more than 30%), to be used in efforts aimed at increasing protein levels.

Water absorption studies

Thirteen materials were selected for this study based on color and size. Absorption levels were measured after soaking for 15 minutes, 30 minutes, 1, 2, 4, 8, 16, and 24 hours. These measurements were correlated to 40 physical, chemical and agronomic variables. Analyses indicated that water absorption characteristics can be differentiated into three distinct groups, as classified in Table 4. A multiple regression analysis showed that the most relevant factors to absorption are physical ones. The agronomic characteristics that are significant for water absorption include bean resistance to common mosaic virus and rust.

Effect of planting time on protein content

A study was begun in Palmira in 1985 B and 1986 A using 22 materials from group 70. The results from these preliminary trials indicate that planting time has a tremendous effect on protein content, therefore, the experiment will be continued through several more planting seasons.

Effect of site and planting time on acceptability characteristics of Rojo 70 and Rojo de Seda

Results from plantings of these two materials in Palmira, Restrepo and Quilichao indicate that site is strongly correlated to grain hardness, absorption of water and cooking time. The planting site at Restrepo produced the hardest, least absorbing and longest cooking beans. Seed harvested from the Palmira site were softest, most absorbing, and needed the last amount of cooking. Harvested seed from Quilichao had characteristics between these two extremes. In comparing Rojo 70 with Rojo de Seda, it was found that Rojo 70 had a higher percentage of hard seed; absorbed less water; had highest cooking time; and, lower percentage of solids in the broth; than did Rojo de Seda, in all three sites.

Effect of variety, planting time, and site on acceptability characteristics

Twenty-nine materials were evaluated for this study, in Palmira and Popayan. A strong effect of site was observed on percentage of water absorption, cooking time, percentage of hard seed, and percentage of solids in broth. Results from other studies on effect of site on protein content were also corraborated. The Palmira site produced materials with better acceptability characteristics than did the Popayan site.

Joint CIAT-Italian National Nutrition Institute project

A three year project was begun in 1986 to study tannins, fiber and other factors responsible for the low digestibility of beans. The first stage of this project was initiated in October 1986 with the selection of materials for the study from 120 special lines that were produced in 1986 A in Palmira. An evaluation of digestibility "in vitro" is planned for all materials to be sent to Rome.

Advances in automatic Mattson cookers

The construction and evaluation of a new prototype Mattson cooker was initiated this year, with the objective of increasing laboratory efficiency. This new cooker will give more precise measurements, and better test sampling in a shorter time, while being safer for technicians. It will also facilitate kinetic studies of the cooking process with in turn will permit more efficient investigations into important topics including sample variability.

Table 1. Average protein values and percentage of solids in broth by grain color.

Color	Mean protein content (N=1109)	Mean percentage of solids in broth (N=915)
White	25.82[a]	9.00[b]
Cream	24.24[ab]	10.00[ab]
Yellow	23.66[ab]	10.00[ab]
Maroon	24.04[ab]	10.30[ab]
Pink	23.17[ab]	8.60[b]
Red	23.90[ab]	9.80[ab]
Purple	23.19[b]	8.00[b]
Other (grey, etc.)	25.08[ab]	—
Black	24.07[ab]	11.90[a]

Values with the same letter are not significantly different at the P=.005 level according to Duncan's Multiple Range Test.

Table 2. Average cooking times; percentage water absorption and percentage solids in broth by seed coat brilliance.

Brilliance	Mean cooking time (N=918)	Mean percentage absorption (N=928)	Mean percentage solids in broth (N=915)
Opaque	23.90[b]	99.40[a]	10.30[a]
Semibrilliant	24.90[b]	97.80[a]	9.60[b]
Brilliant	25.40[a]	89.80[b]	9.40[b]

Table 3. Average cooking time; percentage of water absorption; and, percentage of solids in cooking broth by seed size (weight per 100 seeds).

Sample size	Mean cooking time (N=918)	Mean percentage absorption (N=928)	Mean percentage of solids in broth (N=915)
25 g	24.20^{a}	90.80^{a}	10.60^{a}
25-40 g	24.50^{a}	96.20^{b}	9.60^{b}
40 g	27.30^{b}	101.50^{c}	8.30^{c}

Table 4. Classification and important factors in water absorption process by various materials.

Group of materials	Behavior: Initial (15 min) (% Abs.water)	Behavior: Final (24h) (% Abs. water)	Most important factors for each group
1	Normal (10%)	High (110%)	
2	Low (5%)	Normal (100-110%)	
3	High (15%)	Low (105%)	Grain hardness, tannins, grain hardness, grain weight, % fiber in seed coat

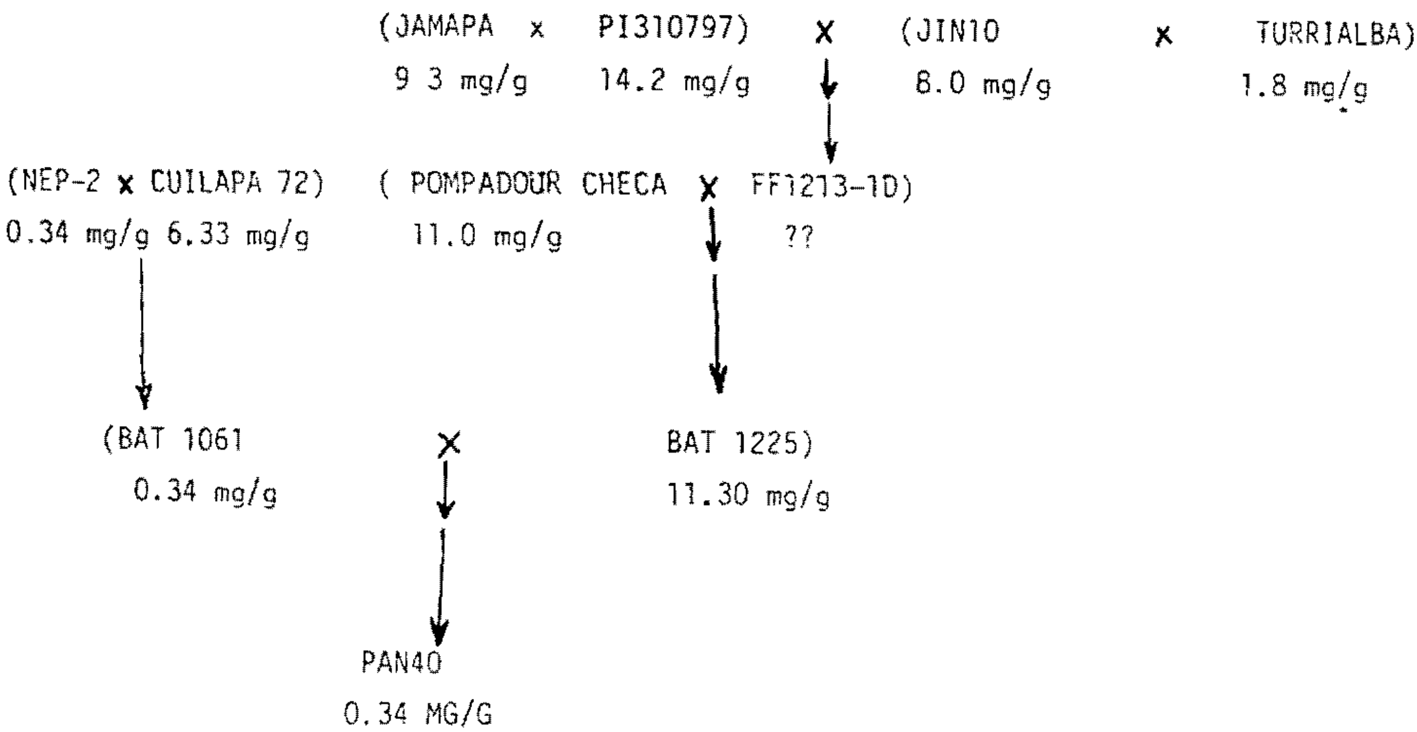


FIGURE 1. The inheritability of tannin levels. Geneology of PAN 40 material.

10. Snap Beans

Snap bean improvement at CIAT has been carried out collaboratively with Washington State University (Dr. M. Silbernagel) since 1983. The principal objective of snap bean improvement has been to incorporate disease resistance and tropical adaptation from the dry bean improvement programs into green beans. The quality attributes sought are stringless pods with either pencil or flat shape. An international adaptation nursery of advanced lines of snap beans was distributed to 14 countries in 1986, including countries in Asia, Africa, Europe and America. The current nursery consists of 204 bush lines, and 32 climbing lines.

Results have been obtained from Iran, Bulgaria, USA, Puerto Rico, Argentina and Colombia. In Bulgaria (Maritza Institute for Vegetable Crops) 109 bush lines were selected for further testing. In Argentina (INTA, La Consulta, Mendoza) the best line was HAB 113, but a total of 84 bush and climbing lines were selected for further trials. In Table 1, the characteristics of the lines which had favorable evaluations in three or more locations are shown. All of these were determinate bush types (growth habit I). There were far more bush types than climbers in the trial, and the climbers possibly show more specific adaptation. All lines were resistant to BCMV, and all were either intermediate or resistant to rust in Colombia, where there is a wide range of races present. Some were intermediate to anthracnose in Popayan, where relatively virulent races, including kappa and delta, are present. Very few showed tolerance to common bacterial blight (CBB). Further work will be needed to improve the resistance to these last two diseases. The locations from which results have been obtained were diverse, and yet HAB 63 was selected in five out of six locations.

In collaboration with ICA, Colombia, a regional trial of bush and climbing snap bean lines was distributed in 1986, consisting of 19 bush lines and 14 climbing lines. Results from six trials planted in Dagua, near Cali, show that anthracnose is particularly important in this area, and resistance was shown by all the climbing lines, of which the best were HAB 208, HAB 214, HAB 232, HAB 234, HAB 235, and HAB 236. Resistance to anthracnose was shown by bush lines HAB 87, HAB 141 and HAB 173, and these lines are also resistant to rust and BCMV. Farmers have shown interest in obtaining more seed of these lines.

Table 1. Characteristics of snap bean lines which were selected in three or more locations.

	Location 1	2	3	4	5	6	Growth Habit	Seed Color	BCMV	Rust	CBB	Anthracnose
HAB 4		*		*		*	I	1	N	R	S	S
HAB 16		*	*		*		I	8	N	I	A	I
HAB 19	*	*	*	*			I	8	N	I	S	S
HAB 20		*	*	*			I	8	N	I	I	I
HAB 27		*		*	*		I	8	N	I	S	-
HAB 29	*				*	*	I	8	N	I	S	S
HAB 30				*	*	*	I	8	N	R	S	-
HAB 41		*			*	*	I	1	N	R	S	I
HAB 43	*	*		*	*		I	9	N	R	S	S
HAB 54	*				*	*	I	8	N	I	S	S
HAB 63	*		*	*	*	*	I	8	N	R	S	S
HAB 66			*	*	*		I	1	N	R	S	I
HAB 67				*	*	*	I	1	N	R	S	S
HAB 84		*	*	*	*		I	1	N	R	S	S
HAB 97		*	*	*	*		I	1	N	R	S	S
HAB 103	*		*	*			I	1	N	R	S	S
HAB 104	*		*	*			I	1	N	R	S	S
HAB 108			*	*	*		I	1	N	I	S	S
HAB 132		*		*	*		I	1	N	R	S	I
HAB 141	*	*			*		I	1	N	R	I	I
HAB 148			*	*		*	I	1	N	R	S	I
HAB 174			*	*		*	I	1	N	R	S	I
HAB 180		*	*		*		I	1	N	R	S	S
HAB 183			*	*	*		I	1	N	R	S	I
HAB 191			*	*	*		I	1	N	R	S	S
HAB 195	*		*		*		I	1	N	R	S	I

Locations : 1 = Palmira, Colombia
2 = Prosser, USA
3 = Mendoza, Argentina
4 = Karaj, Iran
5 = Plovdiv, Bulgaria
6 = Mayaguez, Puerto Rico

Sites where a particular line performed well are marked with an asterisk (*)

Seed color : 1 white, 8 = black, 9 = other colors (dark).
BCMV : N = resistance due to presence of dominant I (necrosis) gene.
Other diseases: R = resistant; I = intermediate; S = susceptible, evaluated in the 1985 VEF nursery in Colombia.

C. Evaluation in Uniform Nurseries

The three-stage progeny evaluation program tested 1902 materials in 1986, of which 67.4% were new entries. The distribution of these materials among the nurseries was as follows:

First stage (VEF):1282 entries
Second stage (EP): 435 entries
Third stage (IBYAN): 185 entries

Table 1 shows the number of sets of these nurseries distributed to different countries during 1986. Complete information of the performance of all entries in each nursery is published every year in VEF, EP, and IBYAN reports, available at CIAT.

1. VEF

1282 entries were distributed in 10 groups according to seed color and size, growth habit (climbing and bush) and climatic adaptation (for climbers only). Table 2 shows the frequency of lines within each group with resistant or intermediate reaction to the five most widespread diseases in beans. The frequency of growth habits and days to maturity within each group are recorded in Table 3. The highest yielding lines within each group with the best combination of performance with regard to the major diseases present in our main Colombian testing sites are shown in Table 4.

2. EP

From the 1451 entries tested in the 1985 VEF, 435 were selected for evaluation in the 1986 EP. Lines were grouped according to growth habit, seed size and commercial grain type. Complete data on all evaluations including yield are shown in the separate yearly publications. Best yielders bush lines in Palmira and Popayan are shown in Tables 5 and 6 respectively. Climbing lines were divided according to their climatic adaptation; results for the small-seeded lines adapted to medium climates are shown in Table 7. Large seeded climbing lines for cool climates were tested in Rio Negro and the results are shown in Table 8.

3. IBYAN

This report includes the results of the 1986 IBYAN trials conducted in Colombia and a summary of the worldwide results of the 1985 IBYAN.

1985 IBYAN

In 1985, 280 trials were distributed. The outstanding lines by market classes are shown in Table 9.

1986 IBYAN

Nurseries were formed considering market classes; 140 nurseries were dispatched to 26 countries. The present report only includes results from the trials planted during the first semester of 1986 in Colombia (Table 10, 11).

Table 1. Number of sets of international nurseries (VEF-EP-IBYAN) dispatched during 1986 to different countries.

COUNTRIES	No. of sets		
	IBYAN	EP	VEF
Angola	2		1
Argentina	4	1	2
Austria		1	2
Belize	1		
Bolivia	3		6
Bulgaria			1
Burundi		1	7
Brazil			3
Colombia	48		
Costa Rica	6		12
Cuba	7	3	
Cyprus	1		
Ecuador	6		
Ethiopia	6		
El Salvador			5
Philippines		2	3
France	1		
Guatemala		4	4
Greece	1		
Haiti			
Honduras	1		8
Italy	1		3
Kenya			
Mauritius	1		
Martinique	1		
Mozambique	2		
Mexico	1		
Nicaragua			6
New Zealand			2
Panama	5		2
Peru	3	1	1
German Dem. Rep.	2		
Rwanda	3		8
Rep. of South Africa	5	1	18
Uruguay	2	4	4
USA			3
Venezuela	8		
Zambia	19		14
Total	140	18	115

Table 2. Number of bean entries in the 1986 VEF with resistant (R) or intermediate (I) reaction to rust, anthracnose, angular leaf spot, common bacterial blight and a necrotic (N) or mottled (M) reaction to bean common mosaic virus.

GROUP		TOTAL	Rust		CBB		ANTR		ALS		BCM	
		Lines	R	I	R	I	R	I	R	I	N	M
Black	10	115	1	9	1	9	3	7	–	10	10	2
Small red	20	131	12	11	1	22	16	7	1	22	23	17
Med/large red	25	175	62	2	–	64	47	17	–	64	64	66
Small white	30	184	6	18	–	24	10	14	1	23	24	8
Large white	35	9	1	–	–	1	–	1	–	1	1	–
S N Coast of Pacific	40	8	1	2	–	3	–	3	–	3	3	2
Mexican Highlands	45	125	15	50	–	65	50	15	–	65	65	3
Brazilian	50	234	6	77	–	83	56	27	–	83	83	7
Climbing-warm climate	70	18	–	4	–	4	4	–	–	4	4	10
Climbing-cool climate	85	283	3	17	–	20	19	1	1	19	20	241

Table 3. Number of bean entries in the 1986 VEF within each group according to growth habit and maturity.

Group	Growth habit				Days to physiologic maturity			
No.	I	II	III	IV	65	65-75	76-85	95
10	-	105	7	-	1	113	-	-
20	-	94	37	-	18	113	-	-
25	142	30	3	-	2	166	4	-
30	65	98	19	-	12	168	4	-
35	9	-	-	-	-	9	-	-
40	4	3	1	-	1	7	-	-
45	3	65	57	-	-	109	14	-
50	5	176	53	-	5	208	17	-
70	-	-	-	-	-	-	-	-
85	-	-	21	262	-	-	-	283

Table 4. Yield (kg/ha) and main characteristics of some outstanding lines in the 1986 VEF within each group.

Line	Habit	g/100 seeds	Maturity	Yield	Rust	CBB	Ant	ALS
Black-small-bush								
NAG 191	2A	20	71	1686	S	S	1	1
XAN 211	2B	22	71	1667	1	1	S	1
NAG 199	3	23	70	1502	1	1	1	1
Red-small-bush								
RAB 367	2B	20	66	1606	1	S	1	1
RAB 360	3	25	70	1552	1	1	R	1
RAB 395	3	40	77	1112	1	1	R	1
Red, pink, red mottled-medium, large-bush								
AFR 289	1	51	71	1378	R	S	S	R
AFR 313	2B	51	72	1413	R	1	1	1
AND 419	3	40	77	1112	R	1		
White-small-bush								
PAN 183	2B	17	68	1309	1	S	R	1
PAN 179	3	40	74	1244	1	1	S	1
Mexican Types-medium-bush								
TY 3347-4	2B	30	71	1326	R	1	R	1
MX 2500-22	3	32	71	1575	1	1	R	1
Brazilian types-small-bush								
TY 3388-2	2A	22	71	1604	S	1	R	1
BZ 4578-1	3	21	71	1892	R	S	R	1
BZ 1358-8	3	23	72	1745	S	1	R	1
Red, cream, mottled-large-climbing-root climates								
AND 433	3A	52	135	4793	1	1	R	1
AND 614	3B	49	135	4295	R	S	R	I
AND 476	4A	61	135	6598	1	S	R	1
LAS-1-89	4B	55	143	6018	1	1	R	1

Table 5. Average yield (kg/ha) of the bush lines tested in Palmira, Colombia. 1986 EP. Semester A.

Small Seeded Entries

Blacks		Cream	
Africa 104	2872	EMP 169	1997
G 17660	2533	AFR 102	1580
Jamapa (c)	2147	Carioca (c)	1597
Mean (n=36)	2061	Mean (n=15)	1284
$LSD_{.05}$	147	$LSD_{.05}$	140
CV	18	CV	28

Reds: Type II		Reds: Type III	
RAB 298	1795	RAB 285	2122
RAB 332	1793	RAB 314	1935
A 21 (6)	968	A 21 (c)	1251
Mean (n=20)	1288	Mean (n=16)	1425
$LSD_{.05}$	97	$LSD_{.05}$	197
CV	26	CV	26

Large and Medium seeded entries

Red/pink: solid and mottled

Medium seeded entries		Large seeded entries	
Africa 158	2570	AND 260	2023
ICA 15111	2459	AND 361	1998
AND 311	2426	AND 276	1920
Checks:		Checks:	
BAT 1297	2379	BAT 1297	2195
Calima	1712	Calima	1346
Mean (n=49)	1626	(n=42)	1443
$LSD_{.05}$	124		110
CV	26		24

Table 6. Average yield (kg/ha) of the bush lines tested in Popayan, Colombia. 1986 EP. Semester A.

Small seeded entries

Blacks

	NAG 124	2299
	NAG 121	2260
	Jamapa (c)	2147
Mean	(n=36)	1837
$LSD_{.05}$		87.8
CV		11

Cream

	EMP 169	2066
	AFR 80	1846
	Carioca (c)	1265
Mean	(n=16)	1284
$LSD_{.05}$		126.1
CV		28

Reds: Type II

	RAB 332	1693
	RAB 288	1632
	A 21 (c)	1419
Mean	(n=20)	1372
$LSD_{.05}$		76
CV		12

Reds: Type III

	EMP 155	1699
	RAB 308	1581
	A 21 (c)	1328
Mean	(n=16)	1341
$LSD_{.05}$		103
CV		11

Small White: Types II -III

	PAN 135	2037
	BLM 14	1863
	Ex Rico 23 (c)	1682
Mean	(n=16)	1494
$LSD_{.05}$		138
CV		20

Type IIa

	VF2 162	1890
	PAN 118	1845
	Ex Rico 23 (c)	1797
Mean	(n=30)	1574
$LSD_{.05}$		76
CV		15

Medium seeded entries

Yellow - Light tan

	CAN 31	2126
	BAN 42	2083
	Mayocoba (c)	1076
Mean (n=25)		1412
$LSD_{.05}$		87
CV		32

c = check

Table 7. Average yield (kg/ha) of the climbing large-seeded lines for cool climates. 1986 EP. Rio Negro, Antioquia.

LINE	YIELD	LINE	YIELD
AFR 239	2611	AFR 54	2034
AFR 142	2586	AFR 64	1864
AFR 227	2321	AFR 58	1801
Check: Rojo 70	2010		2016
Mean (n=28)	1683	(n=42)	1562
$LSD_{.05}$	176		85
CV	32		22

Table 8. Average yield (kg/ha) of the climbing large-seeded lines for cool climates. 1986 EP. Rio Negro, Antioquia.

	LINE	YIELD	LINE	YIELD	LINE	YIELD	LINE	YIELD	LINE	YIELD
	AND 231	5550	AND 135	5164	ZAV 106	4861	ZAV 23	5647	ZAV 66	5846
	AND 221	5163	AND 160	4701	ZAV 85	4847	ZAV 12	5562	ZAV 204	5840
	AND 5	5101	AND 257	4553	ZAV 206	5771	ZAV 98	5502	ZAV 97	5434
	AND 224	5012	AND 243	4553	ZAV 140	4763	ZAV 163	5330	ZAV 101	5432
					ZAV 221	4549	ZAV 154	5298		
Check: ICA VIBORAL		3696		3064		4460		4589		4450
Mean (n=24)		4075	(n=36)	3655	(n=18)	4216	(n=47)	4367	(n=35)	4370
$LSD_{.05}$		268		206		207		213		202
CV		18		20		12		11		17

Table 9. Yield (kg/ha) of the top three lines in the 1985 IBYAN within each group of market classes.

CLASS	LINE	YIELD	$\bar{X}$	$LSD_{.05}$	CV	No. of Sites
Black Type IIa	NAG 13	2216				
	NAG 12	2064				
	Jamapa	2044	1976 (n=13)	182.7	13.4	16
Type III	NAG 28	2082				
	BAT 304	2044				
	NAG 81	2037	1907 (n=15)	254.2	18.3	11
Small Reds	RAB 102	2239				
	XAN 155	2222				
	RAB 128	2174	1919	225	18.3	9
Red Kidney	PVA 1097	1365				
	PVA 1435	1360				
	PVA 1117	1315	1226 (n=18)	18.27	15.9	9
Red Mottled: Warm climate	PVA 340	1677				
	PVA 1216	1626				
	PVA 774	1578	1416 (n=18)	180	15.1	8
Medium climate	PVA 1025	1533				
	PVA 773	1500				
	PVA 1374	1461	1349 (n=17)	259.8	17.3	6
Small White	XAN 134	1924				
	BAT 1715	1788				
	BAT 1712	1757	1577 (n=12)	476.0	24.9	6
Large White	WAF6	1331				
	WAF14	1276				
	WAF7	1175	927 (n=19)	291.0	22.6	5
	WAF9	1894				
	WAF14	1569				
	WAF 16	1452	1280 (n=20)	569.0	24.8	7
Ojo de Cabra/Bayos	ZAV 8306	2486				
	MAM 7	2428				
	ZAV 8314	2379	2149 (n=14)	605.4	12.0	4

Table 10. Yield (kg/ha) of the most outstanding bush lines in 1986 IBYAN within each class of beans. Palmira. Semester A.

CLASS	LINE	YIELD	LOCAL CHECK	YIELD	LONG TERM CHECK	YIELD	X	$LSD_{.05}$	CV
Black	NAG 98 DOR 227	1446 1258	BAT 271	1167	Jamapa	982	1007	567	34
Small Reds: IIa	RAB 175 RAB 244	1350 1223	Zamorano	790	A 21	1085	947	543	33
II	RAB 211 RAB 251	1355 1346	Zamorano	771	A 21	1138	1075	499	28
III	RAO 33 RAB 201	1797 1724	Zamorano	1067	A 21	1629	1430	501	21
Red Kidney	ZAA 105 KID 3	1198 986	Calima	827	BAT 1297	957	776	233	18
Sugar & Cranberry	PVA 800B PVA 3025	1052 961	Calima	848	BAT 1297	401	732	263	22
Small Red mottled	PAT 6 PAI 127	1655 1471	Calima	1046	BAT 1297	1218	1206	352	18
Large Red Mottled	PVA 844 PVA 846	1488 1408	Calima	1159	BAT 1297	1630	1168	384	20
NAVY	PAN 65 PAN 82	1175 1038	BAT 482	992	Ex Rico 23	780	856	422	30
Peruano	Ahome G 13094	1124 1000	997-CH73	654	Mayocoba	609	776	435	33
Jalo - Ojo de Cabra	COS 4 COS 5	1523 1038	A 445	1199	A 321	1639	1016	523	30
BAYO	BAN 33 BAN 28	1351 1097	Brasil 2	828	Titan	1284	822	400	29
Rosinha	RIZ 45 EMP 143	2016 1919	A 295	1294	IPA 7419	1304	1450	522	21

Table 11. Yield (kg/ha) of the most outstanding bush lines in 1986 IBYAN within each class of beans. Popayan. Semester A.

CLASS	LINE	YIELD	LOCAL CHECK	YIELD	LONG TERM CHECK	YIELD	$\bar{X}$	$LSD_{.05}$	CV
Black	DOR 241	2393	BAT 527	1719	Jamapa	1915	1841	482	16
	NAG 98	2350							
Small Red: II a	RAB 244	1971	Zamorano	1516	A 21	1418	1567	224	8
	RAB 210	1851							
II	RAB 211	1995	Zamorano	1608	A 21	1731	1666	572	21
	RAB 230	1994							
III	RAB 201	2055	Zamorano	1332	A 21	1462	1543	416	16
	RIZ 53	1688							
Red Kidney	ZAA 64	1967	Calima	1715	BAT 1297	1696	1527	302	12
	ZAA 105	1777							
Sugar & Cranberry	PVA 800A	1905	Calima	1547	BAT 1297	1518	1529	348	14
	PVA 1384	1838							
Small Red-Mottled	PAT 5	2170	Calima	1414	BAT 1297	1637	1794	251	8
	PAI 127	2082							
Large Red-Mottled	PVA 3026	1593	Calima	1248	BAT 1297	1272	1234	284	14
	PVA 844	1460							
Navy	PAN 87	1711	BAT 482	1284	Ex Rico 23	1560	1323	368	17
	PAN 72	1605							
Peruano	G 13094	1605	997-CH73	1824	Mayocoba	1388	1395	447	17
	Ahome	1592							
Jalo/Ojo de Cabra	CO55	1806	A 445	1693	A 321	2089	1311	260	12
	COS 3	1564							
BAYO	BAN 33	1974	Brasil2	1719	Titan	1310	1347	552	25
	BAN 28	1097							
Rosinha	RIZ 32	2370	A 295	1386	IPA 7419	1758	1713	588	21
	RIZ 46	1961							

D. Regional Activities

1. Central America and the Caribbean

The Central American and Caribbean Bean Project is financed by COSUDE and covers tropical Mexico and Panama as well. In 1986, the project placed greater emphasis on transferring technology generated by the national programs to the farmers, through efficient on-farm research. IICA and ICTA in Guatemala continue to give invaluable logistic support to the project.

In 1986, the participating project countries assumed leadership of the technological research directed at solving the problems of bean production in the region. An efficient network of information and material on beans was formed, and was furthered by active exchanges between the countries.

Research into Bean Golden Mosaic Virus continued to be led by Guatemala in conjunction with Mexico, El Salvador and the Dominican Republic; Apion research was led by Honduras, with the assistance of Guatemala, El Salvador, Mexico and Nicaragua; Honduras also headed slug research in collaboration with the Escuela Agricola Panamericana; web blight was the responsibility of Costa Rica and the Dominican Republic, Guatemala and Panama; Common Bacterial Blight research was directed by Cuba; and, on-farm research trials were led by El Salvador, Honduras and the Dominican Republic.

National programs continued to exchange scientific personnel through participation in courses offered by the various countries, and exchanges were encouraged also in an attempt to minimize work methodology differences among the participating nations of the project.

The network has been reinforced substantially by workshops aimed at analyzing results from the Adaptation Nurseries in the Caribbean and Central America. Courses were oriented towards the training of on-farm researchers to ease technology transfer between national programs and farmers. A strategy for increasing seed production was initiated with a pilot course on the use of "artesanal" (farmer-produced) seed. Project leaders were scientists from the training and service sections of national programs. National program leaders held meetings to discuss research results and to plan future research.

During this year, materials more tolerant to web blight were produced by Costa Rica's Inter-Institutional Bean Program. A new variety was released to the farmers under the name Cariari. Guatemala produced an early variety shown to be more tolerant to BGMV than ICTA Quetzal or ICTA Tazumal, and it was given the name ICTA Ostua. Costa Rica and Cuba adopted two varieties this year - Negro Huasteco and Centa Tazumal - and in the Huasteca region of Mexico, the variety Negro Huasteco 81 was widely adopted by the farmers over a traditional variety, Jamapa.

To aid the countries in production of basic seed, large quantities of seed were sent to Dominican Republic, Cuba, Honduras and

El Salvador. Economic studies in Guatemala indicate that the best varieties for the southeast were adopted by farmers for use in Peten but their use was limited by the lack of seed. In Honduras and El Salvador, new lines about to be sent to the farmers will not have commercialization problems and will be readily accepted by the consumers. Costa Rica became an exporter of beans for the first time this year, in both beans for consumption and in basic and certified seed.

Investigation activities

APION

For various reasons, the Central American Network of Apion Research folded in 1984/85. A reconstruction of the network was begun by CIAT's Bean Program entomologist. Three technicians from Guatemala, Nicaragua and El Salvador were sent to CIAT for training in Apion. These technicians helped prepare six sets of seed from the International Apion Nursery, two of which will be planted in Guatemala, two in Honduras, and one each in El Salvador and Nicaragua. These nurseries have not yet been evaluated.

A technician from Honduras was named to head up the Apion research for the region. His team has planted the following trials:

1. International Apion Nursery (climbers)
2. International Apion Nursery (bush beans)
3. Effect of planting date on resistance to Apion
4. Effect of plant distribution on resistance to Apion
5. Evaluation of damage caused by Apion in resistant and susceptible varieties
6. Comparison of sampling methods for Apion research
7. Study of Apion phenology

These trials were to be ready for evaluation in January, 1987. Nevertheless, it should be emphasized that in spite of the aforementioned problems, promising, well-adapted materials were found in a new family of crosses derived from G 13614, G 3324, G 3336, and G 3585. If Apion resistance can be found in these highly adapted lines, it would be a significant achievement.

BEAN GOLDEN MOSAIC VIRUS

This year crosses made between parents A 429, DOR 302, and DOR 303, (different from the traditional sources of resistance-Porrillo 70, Porrillo Sintetico and Turrialba 1), produced lines showing true resistance to this disease. These resistant materials were incorporated not only into black, red, mottled, canary and other seed, but also into materials of interest for countries outside the Central American region (e. g., Brazil). ICTA released a new variety called ICTA Ostua (ICTA 81-53) that is more tolerant to BGMV than lines released in 1979. ICTA Ostua also has the advantage of being early and tolerant to web blight.

The materials showing resistance in Guatemala have shown tolerance in the Dominican Republic, El Salvador and Mexico. New materials even more resistant to BGMV have been found, and will be used as parents in future crosses. A total of 765 lines including Pinto, Red Kidney, Great Northern, Red Mexican, and other promising types were evaluated in Monjas, Guatemala and Los Mochis, Mexico. From this group, 108 were selected in both locations for their tolerance (good pod production) although none of the entries was resistant. In the second planting, 895 entries from the Germplasm Bank were tested under heavy disease pressure. Results showed that in terms of foliar symptoms, the best lines were Tejano (G 13744), Pinto Americano (G 13703, G 16100), Gentry 22051 (G 2274), and Garrapatos (G 16059 and G 16065). This last entry is one of the progenitors of A 429, which traditionally has had good BGMV resistance and adaptation to the tropics. Other genotypes showed a tolerant reaction (severe foliar symptoms but considerable pod production). Tolerant Habit I lines included G 14, G 121, G 122, G 254, G 426, G 645, G 648, G 650, G 655, G 719, G 1935, G 4538, G 4450, G 5125, G 5129, G 5724, G 5746, G 10082, G 10085, G 10087, G 10088, G 10089, G 10090, G 10093, G 10094, G 10105, G 10106, G 10345, G 11867, G 13848, G 14045, G 14057, G 14678, and G 16102. Tolerant Habit II and III lines included G 404, G 1058, G 13591, G 13593, G 15599 and G 16246.

All these new materials are being utilized in the crossing program for production of resistant and well-adapted mottled, canary, "azufrado", small red, black, and large red bean types.

WEB BLIGHT

Evaluations of large numbers of segregating populations have continued in Costa Rica. Many of these populations have shown high tolerance to web blight and good adaptability to the region, and some of these populations (black as well as red) have proven superior to the leading tolerant check, Talamanca. Evaluations of two red seeded VEFs; two red seeded VPNs; and four VIMs were conducted. Furthermore, 200 cultivars (criollos) and 1000 new entries to the germplasm bank (BG 941-BG 2000) were planted. Five materials were selected from these: BG 1215; BG 1189; BG 1223; BG 1247 and BG 1260.

The following is a summary of materials screened in the web blight nursery in 1986.

1. F_2 populations: 58 populations were delivered from CIAT with the purpose of identifying transgressive segregants. Of these, the following were noted as being particularly promising:

RAO 2 (Chorotega) x BAT 1235	NAG 116 x Talamanca
Talamanca x MUS 14	NAG 130 x DOR 60
DOR 60 x A 220	NAG 130 x L 81-31
NAG 12 x L 883-2	MUS 6 x RAO 27
MUS 11 x L 883-2	PAI 114 x MUS 15
L 81-31 x NAG 12	BAT 1449 x RAO 2
Talamanca x NAG 12	NAG 12 x RAO 27

2. Fifty-two F_4 families pre-selected for BCMV resistance in CIAT and delivered for evaluation in Costa Rica and Guatemala. Of these, progeny of CENTA Izalco, and some of Orgulloso were especially promising.

3. Selections from Adaptation Nurseries (VAs). Noteworthy were RABs 49, 50, 58, 96, 220, 312, 359, 408, and 434.

4. CIAT's red seeded VEF. Here BRUs 16 and 23 were very good.

5. In a preliminary screening of lines from the Elite BGMV Nursery, Garrapatos, Gentry 22051, Aguascalientes, G 14957, Pinto Americano, Local Kidney JPN, G 14465, and ICTA Ostua presented a favorable web blight reaction.

6. International Web Blight Nursery (VIM): Standouts in Costa Rica, Guatemala and/or the Dominican Republic included many selected last year among advanced lines screened in the breeding nursery, including MUS Lines 3, 28, 29, 33 and 34; XAN 222, 224, 226 and 228; NXHC 10321-7-M (MUS 50), HT 7719-5-2 (MUS 47), HT 7700-1-M (MUS 52), RAB 128, A 237, HT 7716 (MUS 46), BAT 450, NAG 20, and ICTA Ostua. The following table presents the best lines of the VIM based on yield and disease severity:

Line	Severity	Yield Gr/Parcel 1.2 mts.2
MUS 37	5.50	80.4
HT 7700	5.50	77.4
XAN 205	5.50	74.2
A-237	5.75	75.1
RAB 73	5.75	63.4
XAN 225	5.75	52.8
MUS 30	5.75	44.5
MUS 33	5.75	34.2
RAB 377	5.75	32.1
XAN 222	6.00	68.6
HT 7719-5-2-M	6.00	67.7
XAN 176	6.00	65.9
RAB 408	6.00	65.9
BAT 450	6.00	64.1
ICTA 883-2-M	6.00	64.8
HT 7716	6.00	48.8
XAN 197	6.00	47.3
NEGRO HUASTECO	6.00	45.2
NAG 20	6.00	44.3
ORGULLOSO	6.00	31.9
MUS 29	6.00	29.2
MUS 36	6.00	29.1
TALAMANCA (TOLERANT)	6.10	37.9
BAT 1155 (SUSCEPTIBLE)	8.00	9.3

With so many promising materials it is evident that a more critical evaluation is necessary to distinguish the best lines. Recommendations from the International Web Blight Workshop (November 1986) suggested yield studies of the best materials under moderate disease pressure across several environments, in order to better discriminate superior genotypes based on yield.

Trials were also conducted on cultural disease control methods, such as crop rotation, planting density, and the use of varying planting distances in hillocks versus rows. The benefits inherent in the "hillock planting" were clearly demonstrated by higher yield and greater tolerance to web blight. Hillock planting permits greater aeration and better drainage.

Research on the effect of herbicides on mulch formation continued, as did studies on the interaction between herbicides and the pathogen (Thanatophorus cucumeris).

Studies on tin-based fungicides like Supertin (48%), Brestan (60%) and Duter (40%), showed that all three of these were superior to the traditionally used Benlate. These studies also determined ideal application rates for these fungicides. Benlate and Supertin are being compared for their utility against systemic fungal infections. Trials have shown promising results from two soil-applied fungicides, tolcofloxmethyl (Rhizolex) and PCNB, which reduce initial inoculum levels.

The most important observation regarding integrated control is that farmers are beginning to adopt the system, and that inexpensive fungicides with low tin levels were superior to the more traditional and expensive product, Benomyl, in commercial bean growing plots. This finding will permit a 25% reduction in the cost of disease control for web blight.

SLUG CONTROL

Studies were continued on developing methods for eliminating slugs and included testing the usefulness of a pelletized bait of maize mixed with Sevin, Dipterex, or Lannate and bicarbonate of soda (as a fermentation inhibitor). This bait has been tested in on-farm trials and in large demonstration plots, and farmers have already been encountered adopting this technology.

Identification of screening sites in Colombia relevant to Central America

The 1985 Annual Report included a study on genotype x environment interaction based on some 15 environments in Colombia and Central America.

This study included 27 genotypes representing both bred and land race materials. This study has been continued in both Central America and Colombia, in order to confirm previously obtained results, and to more finely tune environments in CIAT to correlate better with Central American environments.

Tests were conducted in Santander de Quilichao under lower fertility conditions than previously used, as well as in two sites in Costa Rica, one of which was under moderate fertility stress. This discussion focuses on correlations among experiments which could be considered to have a degree of fertility stress (particularly low P). These experiments were conducted in Guatemala (2), Costa Rica (1) and Santander (1) (Table 1). Only one correlation was significant among all experiment results from these three sites. Santander (with low fertility) correlated with only one of the low fertility sites in Central America (one in Guatemala) However, the Santander low fertility site correlated fairly well with the Santander high fertility site in the same season (r = 43*), and these two studies showed practically the same pattern of correlations with other sites. In other words, in these studies, response to soil fertility did not seem to be an overriding factor in determining adaptation, even though several land race genotypes were included, which were thought to be relatively better adapted to poor soil conditions. It is worth mentioning that low fertility experiments often suffer more disease pressure, probably due to the host's predisposition to the pathogen, and differential response to pathogens will mask the effects of low soil fertility. This has important implications for all work done under low fertility.

This study will continue to search for the best combination of site, fertility level etc. in Colombia to match that of Central American sites.

Table 1. Correlations between yields of 27 genotypes in four low to moderate fertility regimes, and two high fertility regimes (extracted in part from CIAT Annual Report, 1985).

	GUA-1-M	GUA-2-R	BDC-2-M*	STQ-2-M	STQ-2-M	STQ-1-M
GUA-1-M		.30	.30	.12	.33	.32
GUA-2-R			.15	.58**	.43*	.04
BDC-2-M				-.11	.02	.24
STQ-2-M (low)					.43*	-.19
STQ-2-M (high)						.25
STQ-1-M (high)						
X, yield, kg/ha	.89	.41	.93	1.31	2.16	1.41
	Experiments with low to moderate fertility				Experiments with high fertility	

* BDC-2-M = Brisas del Cajon, Costa Rica, in second season in monoculture. See CIAT Annual Report, 1985 for explanation of other sites.

Nurseries

Meetings held in 1986 with the national programs of the project countries resulted in a crossing program that CIAT will carry out for the diverse regional subprojects.

In January 1986, representatives from the different national programs met at IICA in San Jose, Costa Rica to discuss the results of the 1985 VAs and to plan activities for 1986. For the first time, in May 1986, a similar meeting for the Caribbean countries and Panama was held at CESDA, Dominican Republic. Participants in both meetings decided to form an adaptation nursery on a regional basis, to be called VIDAC. The majority of the lines in this nursery will come from the national programs, while some will come from CIAT's improvement program. This nursery will permit the growth of horizontal transfer between participating countries according to their needs.

Vertical transfer is effected from CIAT, through specific country projects, or though the VAs and VEFs as well as through the continuation and dispatching of IBYANs.

Adaptation nursery (VA) Bean team nursery (VEF)

Bean team nurseries (VEFs) were begun this year with red and black grains as well as red climbers and mottles, rather than having adaptation nurseries. The small red bean VEF has been sent to Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala and Cuba; the black bean VEF has been planted in Guatemala and Costa Rica, Cuba and Mexico; and the mottled bean VEF has been planted out in Cuba, Dominican Republic and Panama.

VINARs and EPRs

The project collaborated in the preparation of the EPRs (Preliminary Yield Trials) and VINARs (National Yield Nurseries) with the production and transfer of basic seed to them. Seed was distributed in the following manner:

El Salvador : RAB 203, RAB 58, RAB 204, RAB 213, ZAV 8344.

Honduras : RAB 34, RAB 39, RAB 49, RAB 50, RAB 52, RAB 205, RAB 142

Guatemala: Porrillo 70, Negro Huasteco 81, XAN 112, HT 7716, HT 1719, BAT 450, XAN 93, BAT 76, REV. 81, XAN 90, NAG 101, DOR 2271, NAG 97.

Costa Rica: BAT 76, HT 7716, XAN 90, BAT 1449.

Dominican Republic: MCD 251, PAT 11, PAT 6, PAT 9, RIZ 30, PAD 43

VICARs

A partial analysis was made this year of VICAR Reds 85 and VICAR blacks 85 from 18 locations and results were sent to the VICAR coordinator in El Salvador, since the PCCMCA meetings were held there that year. The best yielding red varieties were: RAB 58, RAB 204, RAB 213, RAB 59, RAB 203 and CENTA IZALCO. All of these were evaluated on-farm and reached average yields of 1400 kg/ha. The comparison of yields of red and black varieties shows that the bean program has significantly improved red varieties which, over the past several years, have always trailed the blacks in yield by approximately 30-40 percent. It should be noted that color stability in the red grains was also achieved.

32 VICARs were distributed for planting in 1987 to El Salvador, Nicaragua, Dominican Republic, Mexico, Costa Rica, and Honduras, which included material for National Programs as proposed at the PCCMCA meeting. These materials were also sent to countries outside the region, e.g. Venezuela and Costa Rica.

On-farm trials

Seed transmitted diseases are an important cause of low yield in the majority of bean producing regions of the project where crop production problems have been analyzed. Therefore, on-farm research has emphasized quality improvement of varieties and/or lines that have been selected for disease resistance, using appropriate agronomic practices. Good resistant seed has been found in the following countries:

GUATEMALA Plantings of the variety ICTA OSTUA were carried out by extension agents from DIGESA in the first season. Transfer trials were planted in the Oriente 83. The lowest yield (500 kg/ha) was obtained from a maize-bean intercrop while the highest (3,400 kg/ha) was obtained from a monoculture planting.

DIGESA bought 600 pounds of CITA OSTUA from the farmers who had the best seed from the first season harvest and planted it in 66 transfer plots in the second season. The acceptability of ICTA OSTUA to farmers and consumers in these areas is being studied.

A variety trial was planted by ICTA in Peten in which 30 entries were planted in three sites with three replications. The superiority of the variety ICTA Tamazulapa under web blight pressure was proven. ICTA also planted experimental plots with ICTA Tamazulapa. 65% of the farmers liked this variety, even though yields were somewhat low due to unfavorable environmental conditions. Farmers wanted to continue planting ICTA Tamazulapa but it was only available in small quantities at 5, 10, and 25 lb bags. This was a major obstacle to its distribution.

Results from three sites with four repetitions show that the economic return of the best treatments ranged between 60-144 %.

HONDURAS. Nine variety trials were planted in five sites: two in Olancho, one in Talanga, one in Esperanza, two in Yoro and two in Occidente. Data based on pod load, earliness, and plant health showed that RAB 205, RAB 50 and, the Honduran Composite Cross (RAB 205 + RAB 50 + RAB 49) all performed very well.

Regional extension workers supervised the planting of forty experimental plots in Paraiso with RAB 205 and RAB 50. Although drought was prevalent, the majority of these plots reached harvest. Farmers were satisfied with these two materials, primarily because of their earliness.

EL SALVADOR. Trials were conducted in the Central region with the varieties RAB 204, RAB 213, RAB 58, MMS 101, Rojo de Seda, and Centa Izalco. Farmers' checks were severely attacked by common bacterial blight and BCMV. MMS 101, Rojo de Seda del Centa, and Centa Izalco were affected by the two diseases to a lesser degree. RAB 204, RAB 213 and RAB 58 were less susceptible to common bacterial blight, and none showed reaction to BCMV, indicating these lines had an I gene incorporated into them.

RAB 58 matured late in all regions, and for this reason most of the harvest was lost. RAB 204 was found to be superior, and was planted in validation and demonstration plots in the second planting season.

In Santa Cruz Porrillo, a study of the following materials was begun: ICTA 883-2-M, Talamanca, ICTA CV-85-11, ICTA CV 85-15, ICTA Tamazulapa, NAG 125, and three red seeded lines, RAB 70, XAN 155, and RAB 383.

COSTA RICA On-farm trials were planted with black seeded, web blight tolerant lines that had been shown to be superior to Talamanca under conditions favorable to anthracnose development. These lines, which will be released in the near future, are: HT 7719 (Porrillo Sintetico x BAT 76), and ICTA 883-2-M (ICTA 81-8 x 83). One hundred pounds of genetic seed from these lines were given to MAG and CNP this year. Research involving "frijol tapado" was conducted with the University. Trials were set up involving four lines - RAB 58, RAB 50, ICTA Precoz 2 and ICTA Precoz 3, which were superior to local varieties.

CUBA Evaluations of advanced materials were very effective in selecting promising lines that will be superior to ICA-Pijao (highly susceptible to rust) in the near future. Promising lines are : BAT 58 negro (CENTA TAMAZUMAL), BAT 304, negro (BRUNCA), BAT 832 (negro), BAT 518 (negro), ICA 23 (rojo), BAT 482 (blanco) and A 336 (crema).

Seed multiplication

During this year, seed was multiplied and sent out to the Dominican Republic, Cuba, Nicaragua, Costa Rica, Guatemala, Panama and Honduras. It is hoped that more concrete and effective seed production can be implemented to break the bottleneck currently existent in the transfer of new varieties to the farmers.

Training

In accordance with the needs of national programs, training has continued in the following forms: regional courses, regional country meetings, workshops, and inter-regional and inter-country exchanges of scientific personnel. Participants from all the countries in the region have taken part in these training activities. The major thrust of these sessions has been to train on-farm researchers in three-phased courses emphasizing "learning by doing". National institutions were encouraged to give greater support to training by observing the final results obtained by the course participants.

Workshops provided training for 113 technicians from the Project region, and 213 participated in on-farm research training courses designed to ease the transfer of materials from national programs to the farmer. On-farm research courses were held at El Salvador, Nicaragua and Honduras. Courses on bean production oriented toward research, transfer and promotion of new bean varieties at the farm level, were held in Costa Rica, Cuba and Mexico. The Project collaborated with the Costa Rican program with a course on economic analysis and on-farm trials. A course was held in Guatemala on the use of microcomputers in bean research. In conjunction with CIAT's seed unit, a course on the promotion of "artesanal" (farmer-produced) seed was carried out in Guatemala. Leading farmers, as well as regional extension agents, participated in this course. This course will serve as an example for the region, by facilitating the production of seed to speed the adoption of the new varieties.

Twenty-three technicians from the region attended multi disciplinary and specialized courses at CIAT. Two Master's students from Panama and Guatemala continue their research at CIAT, and one student from Guatemala terminated his work at CIAT and returned home this year.

The Project facilitated visits of technicians between regional programs with the aim of receiving training or to familiarize them with new techniques or evaluation scales. These exchange visits promoted collaboration in various specialities between countries.

A workshop was held at CIAT on the methodology for routine evaluation of acceptability characteristics of beans. Methods used to determine these characteristics varies from country to country and, as standardization would obviously ease information exchange, the creation of a regional network using similar evaluation methods has been proposed.

In collaboration with the Secretary of State for Agriculture of the Dominican Republic, a national workshop on web blight was held. A regional workshop involving the interinstitutional team in Costa Rica (MAG, CNP, VCR, UNA, ONS, and CIAT) was held for Project technicians, and scientists from CIAT and the US; during which existing programs were examined and future plans were made.

An adaptation nursery (VA) workshop was held in January in Costa Rica and was attended by breeders from Central America. This workshop established a flow chart for VA materials on a two year basis. The breeders decided to devote 1986 to the evaluation of potential parents (crossing blocks and other CIAT nurseries) and existing populations from regional projects (web blight, Apion, BGMV, etc). It was decided to hold another meeting in September 1987 to program crosses for advancement to F_2. It was agreed that CIAT would maintain and advance candidates for the VIDAC, the adaptation nursery for Central America. It was also decided to devote 1988 to selection, and to have another VIDAC by 1989 which will be comprised of lines from crosses planned specifically for Central America. A workshop with similar objectives was held in the Dominican Republic with the participation of Jamaica, Haiti, Puerto Rico, Guadalupe and Panama, as the Caribbean bean consuming countries. Conclusions reached at this meeting were very similar to those of the other, except that multiplication of materials for VIDAC would be done in Puerto Rico.

Coordination Meeting

Coinciding with the PCCMCA meeting, a meeting of the Project coordinators was held in El Salvador and included two participants from each country. The Coordinator of the bean program in El Salvador served as the meeting coordinator and discussions were held on future activities, from the general role of CIAT in the region down to specific sub-projects of each country. All participants actively contributed to the decisions made, whether on technology generation, training of Project personnel, or anything else. Participants represented Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Dominican Republic and El Salvador.

Project revision

A team of Swiss scientists along with a CIAT Bean Program scientist evaluated the project to estimate progress achieved in the region. Recommendations for a continuation of the Project (with specific, necessary modifications made to further the evolution of national programs) was sent to COSUDE.

Future plans

The project will appoint a plant breeder for the region to aid in the planning of specific crosses for each national program, and to aid in the evaluation of materials generated by them. The breeder will be stationed in Costa Rica.

Training programs will be continued in Costa Rica, El Salvador, Nicaragua and Honduras. Courses are to be initiated in El Salvador (zones 1 and 2) and in Dominican Republic. Technicians from CIAT and from the region will participate in a bean production course held in Cuba. CIAT's Seed Unit plans to hold courses in "artesanal" seed production in El Salvador and Honduras. An Apion workshop for the region will be held, and workshops on VA evaluations at the farm/field level will be held with visits from all the participating Project countries in Central America and the Caribbean. The Apion workshop will be held in Honduras and the VA workshops in Costa Rica and Cuba.

The Project coordination meeting, along with the PCCMCA meeting, was to be held in Guatemala in March 1987. An executive committee of the Project will be formed from the national program coordinators from the region.

This committee will be responsible for the programming of research sub-projects for each country; will determine the financing of each subproject; and, will plan the different types of training activities.

Annual meetings of national programs will be held to better coordinate national research institution activities such as extension, credit, marketing etc, all of which are important elements in the process of adoption of new materials by the farmers.

2. Brazil

Close collaboration between CIAT and Brazil continued during 1986. Germplasm development was conducted through evaluating the jointly developed crosses in Brazil, rather than selecting the fixed lines in CIAT prior to shipment to Brazil. By the end of 1986, those segregating populations were in the F_4-F_5 generations, ready for adaptation trials in several states throughout the country.

Germplasm development for Brazil

The Bean Program in 1986 emphasized yield evaluations of populations in early generations, to facilitate rapid selection of the better populations from which the best lines can be extracted. Populations were planted in the field using a lattice design with two replications. One pod per plant was then removed in each season for further advancement. The subsequent seed from these pods was then planted out in the three experimental stations.

Yield potential was emphasized at Palmira, where high technological inputs and chemical control were employed to promote maximum production.

Fields in Quilichao were fertilized and then inoculated with bacterial and angular leaf spot pathogens.

Plants in Popayan were inoculated with anthracnose. The best plants showing a combination of high yield and good disease resistance will be selected; out of these, further selections will be made for commercial grain color. Progeny tests will be done at Quilichao in 1987 A, and selections from these will be bulked and planted in Quilichao as well as in Palmira to be subsequently evaluated for yield and disease resistance. The material ultimately selected will be sent to Brazil at the end of 1987 to be further developed under local conditions by CNPAF.

A total of 736 segregating populations was planted in Palmira in 1986 A, and 589 populations from these were sent to Quilichao in August 1986. Due to a high incidence of bacterial blight and angular leaf spot, only 54%, or 316 populations, were selected for planting in Popayan in December 1986. These were space planted to permit individual plant selection.

As part of the CNPAF-CIAT agreement, a shipment of 208 populations have already been sent to Brazil in December 1985 to be evaluated.

Projects (Character Improvement)	Crosses	Coded Lines	Segregated pops sent out	Country
Anthracnose	14	-	-	-
Angular leaf spot	3	-	-	-
Drought	19	-	-	-
Low P			11 Dec./85	Brazil
Maturity	152	-	-	-
Yield potential	211	-	-	-
Zones (Character Deployment)				
Brazil	105	343	197 Dec./85	Brazil
Mexico	229	196	90 Apr./86	Mexico
Argentina/West Asia	169	222	55 Dec./85	Turkey
TOTAL	902	761	353	

Germplasm flow to Brazil

In 1986 several seed shipments were received by CNPAF through CENARGEN, comprised of fixed lines requested by the Brazilian scientists for their research projects. The received lines were as follows:

1. White large seeded beans — 18 lines
2. International Bean Anthracnose trials — 100 lines
3. Snap bean lines — 236 lines
4. 1985 VEF Black seeded lines — 102 lines
5. 1985 VEF Cream, Carioca, Tan lines — 92 lines
6. 1985 VEF Red seeded Climbers — 55 lines
7. 1985 VEF Pink lines — 135 lines

CNPAF breeders are now selecting within the 200 segregating populations that entered Brazil in early 1985. Evaluations are made by project emphasis (e.g. diseases, environmental stress such as drought and low soil P, and high yield potential). The disease projects investigating ALS, rust, and bacterial blight were planted separately at different times according to the most suitable climatic conditions. Populations were managed using the single seed descent method, harvesting one pod per plant, and taking one seed per pod harvested.

When a population from a certain disease resistance project proves to be very susceptible to another disease, the whole population is then discarded. Individual plant selection will be carried out in F_4 generations. At F_5, the lines are simultaneously field tested in

Irati, Parana, for anthracnose and in CNPAF for anthracnose, rust, and ALS.

EPR (Preliminary Yield Trial) 1984 - 1986 Results

The second generation of EPR ended in September, 1986. Partial results were reported in the 1985 Annual Report. The following tables from 1 to 5 show the outstanding lines and their common and local checks of the EPR planted in 1985/86, the second year.

In the cream seeded trials, the following ESAL lines: ESAL 506, ESAL 501, and ESAL 507, performed very well in the northeast and central west as did LM 21303, A 295, and 82 PVBZ 1783, A 251, 82 PVMX 1637, and A 321. The averages of the 20 best lines at each location were always higher than the averages of the common checks. The average yields of the local checks in some places yielded the same as the common checks (Table 1). These lines also performed well in the far west region of Brazil, in Vilhena, and Ouro Preto D'Oeste - Rondonia (Table 2).

In the black seeded EPR, LM 30074 was obviously the favorite. It showed up in the 10 best lines in every testing site (except in PESAGRO Campos) in two semesters of testing. This suggests that LM 30074 is the best widely adapted line, followed by NAG 24, LM 20785, W 22-8, and 82 B VAN 39 . Yields of 10 best black advanced breeding lines were significantly higher than those of the common and local checks. The high performances of black lines coincided in years where anthracnose incidence was low (Table 3).

Most of these lines are susceptible to anthracnose and therefore, cannot be selected to participate in the state trials. For the southern part of Brazil, anthracnose resistance is a high priority. The black seeded lines were also tested in southwest and northeast Brazil. NAG-15, DOR 218, 82B Van 40, and NAG 29 outyielded the common and local checks significantly (Table 4). These results are very different from those obtained from the traditional black bean growing regions.

The purple seeded EPR was only planted in three locations, in Ponta Grossa in Parana, Ponte Nova - EPAMIG and Anapolis - GOIAS. The advanced breeding lines showed little advantage; however, LM 30013-0, LM 10069-0, 82 PVBZ 1838, and BAT 41 looked promising (Table 5).

Table 6 summarizes the number of trials shipped, results received, and the number of experiments that could be analyzed statistically from the 1984 - 1986 EPR. About 35% of the results were analyzable and improvement in trial handling is expected with the reorganization of the EPR responsibilities in CNPAF.

The performance of the first and second generation of EPR is summarized in Table 7. In general, the overall yields of the first generation of the EPR were higher than those of the second one. This occurred not only in the experimental lines but also in the common and local checks. The yield differences between the advanced breeding lines (tested lines) and the common check or the local check were minimal. In the second generation the average yield of the local or common checks was slightly better than that of the tested lines. Appreciable yield differences were found only between the average yield of the 10 best breeding lines and the checks. This suggests that too many inferior lines entered the EPR, and that there is an urgent need to test all advanced breeding lines in several locations before they enter the EPR. Table 8 shows the frequency of the 20 best advanced breeding lines participating in the second generation of EPR (1984-1986). Yield range for each line is included in parentheses.

EPR (Preliminary Yield Trial) 1986 - 1988

The third generation of EPR started in September 1986 and will run until September 1988. The EPRs must be somewhat modified this year to satisfy requirements set by several state institutions:

1) The Carioca EPR was created through separation from the Mulatinho group. There are many state institutions in the south, southeast, and centralwest that would like to have a Carioca EPR but not the cream EPR. The northeast, where the cream seeded varieties dominate, can receive the Carioca nursery if requested.

2) The EPR nurseries should become smaller since there are many state institutions that cannot handle large nurseries. By splitting the nursery into smaller nurseries, one hopes that the EPR can be planted in more sites within one state.

3) Inclusion of elite checks in the EPR. Elite checks will be composed of the best lines from the previous EPR, providing a way to measure the progress of EPR over generations.

4) CNPAF will offer observational trials to the state institutions that have the capacity to introduce more entries, parallel to the EPR. These observational trials will be comprised of up to 200 lines of commercial seed types of the region.

To execute this new EPR, three coordinators will be assigned to accompany and be responsible for the experiments in southern, centralwestern, and northeastern regions of Brazil. These coordinators will help the states with the EPR through state trials until the release of the best lines as varieties. Regular regional meetings will be encouraged to compile the regional data. The composition of this 3rd generation EPR is shown in Table 9.

State trials

EMGOPA

Tables 10 and 11 show the results of EMGOPA state trials over six locations for black and colored seeded cultivars, respectively. LM

30074, the best line from the EPR of 1985 was immediately incorporated into the state trials and it proved again to be the best line when compared to ICA COL 10103, BAT 1647, and Porrillo Sintetico, the leading lines of last year. Porrillo Sintetico performed well, not only at EMGOPA but also at PESAGRO/RJ. This suggests that Porrillo Sintetico is adapted to the regions with relatively high temperatures. To the contrary, FT 83-120 did not perform well under conditions of Goias but yielded better than Rio Negro or Rio Tibaji in Parana and Santa Catarina. Most of these outstanding black lines, (with the exception of FT 83-120), are susceptible or very susceptible to common bacterial blight. In the color seeded lines, also tested over six locations, common bacterial blight was a limiting factor as well. Yield from EMGOPA 201-Ouro, a line with resistance to ALS and anthracnose, was reduced drastically by CBB whereas the traditional Carioca lines, although infested severely with CBB and ALS, yielded better. This indicates that CBB reduced the yield more than ALS and that future breeding work should stress CBB resistance for lines grown in relatively high temperature conditions. Commercial seed production of EMGOPA 201-Ouro must be improved to reduce dissemination of CBB infected seed all over the state.

PESAGRO/RIO DE JANEIRO

Bean production of 55,000 t/year in the Rio de Janeiro state is relatively small in comparison to other states such as Parana, Sao Paulo, and Minas Gerais. Rio de Janeiro, however, consumes the majority of black beans produced in Brazil.

Rio de Janeiro has environmental conditions which differ greatly from other states. The outstanding black lines such as LM 30074, BAT 1647, and ICA COL 10103 which are widely adapted all over Brazil are not so well adapted to Rio de Janeiro. PV 99 N, LM 30063, A 222, and EMP 84 proceeding from the first generation of EPR were the best in the state trials (Table 12). These lines will be compared to the best lines from the second generation of EPR (Table 13).

Early maturing materials are in high demand by many farmers because a short cycle bean fits in well with their crop rotation plans, as land is normally idle for 3 months between the two main crops. PESAGRO received an early maturity nursery from CNPAF. The best lines for this nursery significantly outyielded the checks and are listed in Table 14. The highest grain yield/day is obtained by 82 PVMX 1554 followed by BAT 304, CNF 298, and CNF 302. Capixaba Precoce (commercial seed) was used as a check and yielded lower than BAT 304 (basic seed). The yield difference of the same genetic line may be the result of the degradation of the seed quality under commercial seed production. Again, improvement of commercial seed production is urgently needed.

EMPASC - Santa Catarina

The state trials were conducted at 3 locations and showed the superiority of FT 83-120, EMPASC 201, Chapeco, BAT 75, and A 226 in the black seeded group (Table 15). All of these lines are anthracnose resistant. BAT 75 was severely infested by rust and will not be included again in the state trials.

Of the cream seeded types, Carioca performed somewhat better than did A 140 and A 266 (Table 15). Carioca 80 with anthracnose resistance performed more poorly than did the susceptible Carioca lines. Carioca (score 5) is susceptible to anthracnose and Carioca 80 (score 1) is resistant. However, the resistance of Carioca 80 was not reflected in higher yields.

Web blight nursery - UEPAE Porto Velho, Rondonia

A web blight nursery was conducted at UEPAE Porto Velho/Rondonia. Out of 129 lines sent in 1985 to Rondonia, 11 were selected for resistance and another 18 were selected for recovery ability. These were retested, along with the best lines from the EPR (Table 16). Only 25 lines scored lower than 80% disease incidence. Well-known commercial lines such as Talamanca, Huetar, Revolucion 81, Negro Huasteco, and Acasia 4 were all susceptible. The two best lines in the web blight nurseries (BAT 1295 and BAT 1297), had disease incidences of 70 - 90%. EMGOPA 201 Ouro (A 295) and BAT 477 were also susceptible. Since this experiment was carried out in the field without inoculation, disease incidence was not uniform.

Acid soil studies on beans

Screening for low soil phosphorus

This year the screening for low soil phosphorus tolerance included the lines that will participate in the EPL (Ensaio Preliminar de Linhagens = VEF). The evaluation is rather extensive because a new criterion (APMY = additional phosphorus to reach maximum yield), used to select the lines, has been incorporated into the evaluation. This new criterion facilitates better selection of efficient lines with and without reponse. In the past, lines that had an alpha value lower than the average alpha were classified as efficient but non-responsive. However, there were many lines with high yields under low soil P and therefore their alpha becomes low, when alpha is calculated as follows:

$$\text{alpha} = \frac{\text{Yield of non-stress plot - yield of stress plot}}{\text{difference of P applied}}$$

This formula implies that alpha varies within the efficient group (quadrant 1 and 2) to the disadvantage of the most efficient lines (those with high yield under P stress). These most efficient lines have a lower alpha value because the yield differences between the yield of non-stress and yield of stress conditions are small.

On the other hand, lines A 283 and A 252, (Figure 1), fall within the efficient group (quadrant 1 and 2), but have different yields under P stress. A 283 is efficient and responsive, whereas A 252 is efficient but non-responsive. However, both are better than the Carioca check. To make the evaluation easier, a new factor, APMY (Additional P to Maximum Yield) was created. This is the theoretical quantity of P fertilizer needed to raise the yield of those particular lines to to equal the maximum yield of the experiment. It is calculated as follows:

$$\text{APMY} = \frac{\text{Maximum yield of the experiment - yield under P stress}}{\text{alpha}}$$

and is expressed in P kg/ha. With this formula the selection automatically favors the most responsive lines (lines with high alpha values). A low APMY value means that only a small quantity of P kg/ha is needed to increase the yield to reach the maximum yield. Table 17 shows the outstanding lines, grouped in 4 seed colors, under P Stress and their APMY values.

Not many lines in the Carioca group outperformed A 283, A 252, or Carioca. But some advanced breeding lines, such as BZ 3836-1, BZ 3836-2, MX 2759-20, and A 251, were excellent. The additional P to reach the maximum yield ranged from 35 to 150 kg P_2O_5 ha. Carioca needed (theoretically) almost 500 kg P/ha to reach the maximum yield of the experiment, due to its low alpha value.

In the cream seeded group there were more lines that performed better under P stress than the checks: G 4000, G 5059, G 5054, and IPA 74-19. The APMY ranged from 44 to 120 kg P/ha for the 10 best breeding lines compared to more than 200 kg P/ha for the checks.

In the black seeded group, the breeding lines performed better than the checks. ICA Pijao, an inefficient, but responsive line, was selected because it needed only 103 kg P/ha to reach the maximum yield. ICA Pijao has not been selected previous to this experiment, because it was classified as an inefficient line.

The red seeded group looked encouraging when compared to their checks. These checks were susceptible to stress conditions and therefore the advanced breeding lines outperformed them easily. Unfortunately, the P efficient lines have off-red colors, which are not as appealing to consumers.

Rhizoctron results

Collaborative research conducted with the agronomy department of the Federal University of Parana in Curitiba produced the first results on root studies in Rhizoctron. The objective of this study was to determine whether there were differences in the root systems of P efficient and P inefficient lines with the root system being an indicator of P efficiency in beans. Deeper root systems can explore more soil looking for P, suggesting that root system measurements can be an indicator of P efficiency in beans.

Six lines were tested in the Rhizoctron with slanting glass panels. Carioca, Rosinha G2, and A 283 represented the efficient lines in using low soil P, and CNF 10 and A 143 the inefficient lines. Puebla 152 was a good Nitrogen fixer but its efficiency in using low soil P was poor. Soil used in this Rhizoctron was low in P and high in Al+++ which gave an excellent differentiation of lines tested. Figure 2 show the rooting pattern transcribed from the glass panel. Carioca and Rosinha G2 gave the deepest root penetration and reached about 98 cm from the soil surface, whereas inefficient lines such as CNF 10 and A 143 showed more shallow root penetration. There were few differences in root branching, but by superimposing 5 steps of 20 cm. each onto the length of the root some interesting observations can be made. In general, under artificial soil compaction in Rhizoctron boxes, 50% of bean roots grew to a depth of 20 cm and about 30% grew to a depth of between 21 - 40 cm (Table 18). Carioca, Rosinha G2, and Puebla 152 showed root growth deeper then 40 cm except for line A 283. Line A 283 is an acid soil tolerant line tested for several seasons at CIAT-Quilichao. This line showed a unique root distribution in the Rhizoctron. A 283 did not have as deep a root system as Carioca or Rosinha G2, but rather, a dense rooting system at the first 20 cm layer of soil. If this root system pattern is repeated in future experiments, it is likely that this line is low soil P efficient because it can explore the volume of soil in the 20 cm layer. At Quilichao conditions, this coincided with the arable layer. This type of root distribution is not desirable in many other places where occasional short dry spells may occur.

Further work in Rhizoctron will include: measuring the root growth velocity and root growth rate; comparing Rhizoctron results with those from the rooting box, studing distribution of the roots at later stages of growth; and studying root growth under varying water regimes.

Beans under furrow irrigation system

There has been a high demand recently for information on, and seed for, planting beans under partially innundated land known as Varzeas; or under sprinkler irrigation (mostly for winter crops) and under furrow irrigation (for Brazil's Northeast irrigation project). The Brazilian government is promoting the preparation of land for a giant irrigation project. Several government entities have been created to look into the problems inherent in irrigated bean crops. In the next five years the Ministry of Irrigation expects to have 1 million ha of land under irrigation in this part of Brazil. A problem with any type of irrigation system is temporary inundation since perfect land levelling is impossible, and beans do not tolerate flooding, even for short periods. Another problem occurs during land preparation for irrigation, when large scale earth movement is carried out creating non-uniform soil fertility. Information on beans grown under irrigation is scarce. Studies on bean performance under this type of management are critical to obtain useful parameters for screening beans for tolerance to excess water.

Trial for beans grown under Varzeas conditions

A simple yield trial with 3 cultivars was conducted at Palmital experimental station/Goiania. This experimental station has about the same characteristics as the irrigated areas, known as Varzeas. Irrigation can be done by raising the water table. The sloped land chosen for the experiment had a normal water table of 1.5 m. By raising the water level at the canal, a 0.94 cm/m gradient of water table was obtained. The lowest spot had a water table of 9 cm and the deepest one of 26 cm. Beans were planted in the prepared land with good moisture. Watering was done twice during the growth cycle, once at V3 (first trifoliate) and once at R6 (flowering). The period of watering was for 48 hours each time. The water table was then lowered to its normal stand, 1.50 m. Bean yield increased with the increased depth of water table. There were no significant differences in yields among the cultivars (Table 19). Plots with the highest water tables suffered the most. At water tables lower than 9.8 cm, beans started to grow almost normally. However, the deepest water table (11.70 cm) gave the highest yield. This suggests that a high water table, although occurring only twice in the whole growing season, has a detrimental effect on bean growth.

Future experiments will concentrate on temporary inundations which always occur during irrigation with the gravity method or sprinkler irrigation. Varietal differences will be researched.

Table I. The outstanding cream-seeded advanced breeding lines and their common and local checks tested in EPR during 1985-1986 in the northeast and central west of Brazil.

TRAT	IDENTIFICACAO	RIBPOM 85	NSOURE 85	ITABER 85	TIANGUA 85	CARUAR 85	UNIAOP 85	BODOQ 85	STIPAN 85	CNPF 86MF	CNPF 86AF	PONTAG 86	IRECE 85	RIOBR 85	MEDIA
78	ESAL 506	476	1268	826	2860	1433	392	2150	867	725	1221	1539	1333	1107	1246
25	82 PVBZ 1783	570	1417	989	2503	1744	523	1882	950	760	1065	1324	1600	717	1234
24	ESAL 507	248	1109	1002	1617	1758	168	2612	967	874	1394	1738	1050	1073	1201
21	ESAL 501	420	977	735	2408	1411	187	1934	1217	789	1107	1308	1867	1190	1196
7	LM 21303-0	741	1303	958	1882	1284	337	1408	650	998	1515	1473	1300	1083	1149
93	A 251	300	1925	723	1840	1396	303	2275	817	575	903	1539	1333	973	1146
70	82 PVMX 1637	378	1190	807	2072	1370	341	1853	1033	629	748	1208	1650	1180	1112
61	A 321	487	1190	687	2352	1024	241	3020	1150	509	1193	761	867	897	1106
57	82 PVMX 1638	231	1713	612	2090	1493	273	1563	850	588	992	1076	1583	1239	1100
91	A 254	522	1493	713	1615	1317	270	1715	933	999	1188	1937	900	566	1090
47	L 11093	439	721	752	1877	1388	253	2127	1167	669	762	1092	1650	1228	1087
37	A 295	329	1508	979	1670	1452	426	2158	1350	629	818	331	1483	972	1085
56	L 10111	195	1293	908	1750	1307	388	1505	1333	641	883	1754	1100	962	1078
30	LM 21306-0	279	1184	646	2110	1700	255	1341	800	916	910	1572	1400	878	1076
45	82 PVBZ 1770	283	1170	975	1292	1461	310	2343	1317	951	909	679	950	1328	1074
18	L 11090	278	759	899	1865	1611	222	2088	767	518	847	1258	1967	753	1064
10	82 PVBZ 1777	455	1477	710	1913	1331	341	1568	1100	765	898	1192	1083	962	1061
95	ESAL 504	315	2349	529	1453	1144	421	1783	1583	430	1500	579	850	861	1061
31	A 300	482	1422	873	1298	1698	219	2182	1317	419	445	596	1833	989	1059
88	L 10081	452	1312	998	1383	1320	293	1332	1083	798	812	1903	1083	926	1053
X20		394	1339	817	1893	1432	308	1942	1063	709	1006	1243	1344	994	1114
		COMMON CHECKS													
26	JALO EEP 558	366	1941	530	1645	1471	300	1748	1300	935	1588	679	1100	875	1114
52	CORNELL 49242	287	1249	857	1983	1101	324	1955	1317	610	613	1126	1067	1011	1038
51	PARANA 1	381	768	897	1955	1187	185	1712	950	322	384	943	1766	1259	978
83	CARIOCA	319	872	708	2028	1312	310	1754	0	419	626	1423	717	1227	976
16	MUL.VAGEM ROXA	412	1244	789	1135	1272	379	1893	1167	473	620	877	1083	1270	970
3	AROANA	312	694	568	1862	1116	187	1824	700	319	449	1026	1700	712	882
99	IPA 74-19	282	692	931	1095	1096	170	1601	883	262	580	894	1167	1229	837
X7		337	1066	754	1672	1222	265	1784	1053	477	694	995	1229	1083	971
		LOCAL CHECKS													
73	TEST.LOCAL	402	1035	790	2053	1469	152	1608	767	115	251	1159	1667	1753	1017
43	TEST.LOCAL	357	929	542	1603	868	276	1535	1133	403	915	1258	1383	1232	956
14	TEST.LOCAL	374	828	536	1270	1126	256	1908	1283	652	819	558	0	1187	900
55	TEST.LOCAL	324	900	651	0	1128	101	1663	483	859	986	1672	0	791	869
X4		364	923	630	1642	1148	196	1678	916	507	743	1162	1525	1241	935

RIOBR85 = UEPAE - Rio Branco - Acre
BODOQ85 = EMPAER - Bodo quema - Mato Grosso do Sul
CNPF86MF = CNPAF/Goiania 1986 under medium soil fertility
CNPF86AF = CNPAF/Goiania 1986 under high soil fertility
PONTAG86 = COTIA - Ponta Grossa - Parana
UNIAOP85 = EPEL - Uniao das Palmares - Alagoas

RIBPOM85 = EPABA - Ribeiro do Pombal - Northeast of Bahia
NSOUR85 = EPABA - Nova Soure - Northeast of Bahia
ITABER85 = EPABA - Itaberaba - Centersouth of Bahia
TIANGUA85 = EPACE - Tiangua - Ceara
CARUARU85 = IPA - Caruaru - Pernambuco
STIPAN85 = EPEAL - Santana de Ipanema - Alagoas

Table 2. The 10 best cream seeded advanced breeding lines and their common and local checks tested in 1985-1986. EPR; UEPAE Porto Velho, Rondonia.

Local	Vilhena	Ouro Preto D'Oeste	
Identification	Yield (kg/ha)	Identification	Yield (kg/ha)
Advanced breeding Lines:			
1. ESAL 507	392	A 317	378
2. ESAL 506	385	A 254	328
3. 82 PVMX 1535	383	L 11080	325
4. 82 PVBZ 1783	374	82 PVMX 1638	314
5. LM 21306-0	373	LM 00171-1	309
6. A 318	371	L 11086	297
7. LM 21303-0	367	A 295	297
8. LM 10402-0	363	A 154	288
9. LM 21307-0	361	L 11077	287
10. ESAL 508	358	ESAL 505	285
$\bar{X}_{10}$	373[a]		311
Common Checks:			
1. Aroana	357	Aroana	85
2. Mulatinho V.Roxa	295	Mulatinho V.Roxa	120
3. Jalo EEP 558	318	Jalo EEP 558	157
4. Parana 1	323	Parana 1	261
5. Cornell 49242	290	Cornell 49242	283
6. Carioca	295	Carioca	152
7. IPA 7419	136	IPA 7419	108
$\bar{X}_7$	328		167
Local Checks:			
1. Carioca	369	Carioca	16
2. Rosado	248	Rosado	248
3. Rosinha	236	CNFx 0120	197
4. CNFx 0120	164	ESAL 504	313
$\bar{X}_4$	254		194

[a]Statistical analyses were not executed because yields were too low.

Table 3. The 10 best black advanced lines and their common and local checks tested in 1984-1986 EPR over 4 locations in the southeast of Brazil.

	CAMPOS84*		EMCAP8586*		PESAG8586*		PESAG8586*		EMGO8586*	
Advanced breeding lines:										
01	NAG 24	1948	82 B VAN 38	954	V 22-8	1380	BAT 1037	2257	NEGRITO 897	1432
02	W 22- 3	1899	LM 30063	904	LM 21132	1287	LM 30036	2179	W 22- 3	1293
03	W 22-55	1826	NAG 25	899	IPA 74-19	1280	NAG 15	2067	LM 21124	1280
04	NAG 87	1692	LM 30074	858	NAG 24	1259	LM 10360	2048	RICO 1735	1186
05	LM 30063	1664	NAG 26	848	LM 30063	1225	NAG 24	1982	BAT 871	1140
06	82 B VAN 38	1644	LM 21132	834	LM 10364	1223	LM 10364	1959	LM 10360	1137
07	LM 20816	1605	82 B VAN 39	813	LM 21135	1186	82 B VAN 39	1955	82 B VAN 74	1119
08	NAG 26	1554	LM 10360	743	BAT 871	1173	LM 10377	1940	LM 21135	1104
09	LM 20720	1545	W 22-50	742	CNF 0376	1156	NAG 26	1910	LM 10364	1076
10	82 B VAN 39	1505	CNF 295	738	LM 30074	1146	CNF 295	1899	NAG 40	1075
$\bar{X}_{10}$		1853		833		1232		2020		1184
Common Checks:										
01	JALO EEP 558	1131	JALO EEP 558	549	JALO EEP 558	1005	JALO EEP 558	1388	JALO EEP 558	761
02	CORNELL 49242	1550	CORNELL 49242	470	CORNELL 49242	898	CORNELL 49242	1652	CORNELL 49242	529
03	CARIOCA	1479	CARIOCA	606	CARIOCA	1022	CARIOCA	1580	CARIOCA	724
04	RIO TIBAGI	811	RIO TIBAGI	327	RIO TIBAGI	651	RIO TIBAGI	1203	RIO TIBAGI	872
$\bar{X}_4$		1243		488		894		1456		722
Local Checks:										
01	T.LOCAL 1	1391	CAP.PRECOCE	1053	T.LOCAL 1	753	BR1 XODO	2033	EMGOPA OURO 1	819
02	T.LOCAL 2	1470	COSTA RICA 1031	89	T.LOCAL 2	691	BR2 GDE RIO	1350	EMGOPA OURO 2	908
03	T.LOCAL 3	1505	RICO 1735	526	T.LOCAL 3	561	BR3 IPANEMA	1755	EMGOPA OURO 3	844
04	T.LOCAL 4	993	ESAL 1	720	T.LOCAL 4	881	C.PRECOCE	2054	EMGOPA OURO 4	831
$\bar{X}_4$		1340		597		722		1798		851
MEAN(81)		1218		535		908		1595		849
LSD(5%)		524		338		372		609		499
CV(%)		21.9		32.2		20.9		19.5		29.9

* CAMPOS84 = PESAGRO - Campos - Rio de Janeiro; EMCAP8586 = EMCAPA - Venda Nova - Espirito Santo
PESAG8586 = PESAGRO - Campos - Rio de Janeiro; PESAG8586 = PESAGRO - Campos - Rio de Janeiro; EMGO8586 = EMGOPA - Goiania - Goias

Table 4. The 10 best black advanced breeding lines and their common and local checks tested in 1985-1986 EPR in the eastern part of Brazil.

		EMEPA 85[a]	EMCAP 85-86[a]	
Advanced breeding lines:				
01	NAG 15	1833	82 B VAN 40	1625
02	DOR 218	1250	NAG 29	1350
03	LM 00189	1250	LM 20357	1333
04	CNF 375	1167	BAT 1060	1275
05	LM 00574	1167	LM 20816	1258
06	A 231	1083	A 211	1258
07	82 B VAN 39	1000	NAG 40	1242
08	NAG 25	1000	W 22- 8	1200
09	NAG 37	1000	MILIONARIO 1732	1200
10	LM 10426	1000	BAT 871	1192
$\bar{X}_{10}$		1175		1293
Common checks				
01	JALO EEP 558	833	JALO EEP 558	1108
02	CORNELL 49242	500	CORNELL 49242	1058
03	CARIOCA	750	CARIOCA	892
04	RIO TIBAGI	750	RIO TIBAGI	1108
$\bar{X}_4$		708		1042
Local checks				
01	IPA 1	917	VITORIA	983
02	IPA 1	1000	RICO PARDO 896	1975
03	IPA 1	1333	CAPIXABA PREC.	1025
04	IPA 1	583	ESAL 1	1300
$\bar{X}_4$		958		1321
Mean (81 lines)		770		910
LSD(5%)		727		650
CV(%)		48,2		15,8

[a] EMEPA85 = EMEPA - Princesa Isabel - Paraiba
EMCPA8586 = EMCAPA - Venda Nova - Espirito Santo.

Table 5. The 10 best purple advanced breeding lines and their common and local checks tested in 1985-1986 EPR in Minas Gerais, Parana and Goias.

	PONTE 85*		PONTAG 86*		EMGO 85-86*	
Advanced breeding lines:						
01	LM 30013-0	2158	LM 10060-0	1492	LM 10069-0	916
02	LM 10069-0	2152	LM 10009-0	1492	ESAL 503	789
03	82 PVBZ 1838	2142	BAT 41	1410	82 VAR 112	781
04	LM 10100-0	2030	LM 10092-0	1377	LM 10092-0	731
05	LM 10103-0	1975	RAO 23	1295	LM 10093-0	708
06	LM 10415-0	1957	LM 10076-0	1279	LM 10009-0	693
07	BAT 41	1927	DOR 191	1213	LM 30013-0	679
08	LM 10032-0	1878	LM 10061-0	1213	LM 10089-0	651
09	ESAL 502	1873	LM 10065-0	1213	LM 10100-0	648
10	LM 10076-0	1868	LM 10062-0	1197	LM 10102-0	629
$\bar{X}_{10}$		1996		1318		723
Common Checks:						
01	IPA 74-19	1927	IPA 74-19	958	IPA 74-19	589
02	JALO EEP 558	1910	JALO EEP 558	1279	JALO EEP 558	793
03	CARIOCA	2058	CARIOCA	1558	CARIOCA	594
04	CORNELL 49242	2187	CORNELL 49242	1066	CORNELL 49242	589
$\bar{X}_4$		2021		1215		641
Local Checks:						
01	RICOMIG 1896	2100	CARIOCA 80	1656	EMGOPA OURO 1	500
02	18039	1938	RIO NEGRO	1033	EMGOPA OURO 2	568
03	FORTUNA 1895	1868	R.VERMELHO	967	EMGOPA OURO 3	524
04	890	1308	R.PIQUIRI	869	EMGOPA OURO 4	566
$\bar{X}_4$		1803		1131		540
Mean(49)		1772		1027		521
LSD(5%)		547		341		339 CV(%)
15.3		16.9		33.1		

* PONTE 85 = EPAMIG - Ponte Nova - Minas Gerais;
PONTAG 86 = COTIA - Ponta Grossa - Parana;
EMGO85 86 = EMGOPA - Goiania - Goias.

Table 6. Summary of EPR trials executed during 1984 - 1986.

Seed color	Shipped	Data received	Statistically evaluated
Black	42	20	16
Cream and Carioca type	76	32	20
Red/Purple	33	8	8
Total:	151	60	44

Table 7. Summary of the performance of the breeding lines against their common and local checks.

	Black				Cream				Red			
	1 generation		2 generation		1 generation		2 generation		1 generation		2 generation	
Yield	82/83	83/84	84/85	85/86	82/83	83/84	84/85	85/86	82/83	83/84	84/85	85/86
General Average	1543 (n=81)	1275 (n=81)	1422 (n=81)	1370 (n=81)	1446 (n=100)	940 (n=100)	735 (n=100)	1194 (n=100)	NOT TESTED THIS YEAR	1131 (n=49)	809 (n=49)	1278 (n=49)
Exp =	4	10	9	7	5	18	6	13		6	5	3
Average of the ten best lines	1970	1763	2006	1370	1984	1370	1185	1374		1576	1129	1346
Average of tested line	1544 (n=71)	1271 (n=71)	1429 (n=72)	983 (n=72)	1450 (n=88)	950 (n=88)	733 (n=89)	952 (n=89)		1133 (n=40)	808 (n=41)	1307 (n=41)
Average of common check	1510 (n=6)	1279 (n=6)	1396 (n=5)	936 (n=5)	1440 (n=8)	912 (n=8)	788 (n=7)	972 (n=7)		1179 (n=5)	975 (n=4)	1292 (n=4)
Average of local check	1604 (n=4)	1336 (n=4)	1333 (n=4)	1084 (n=4)	1378 (n=4)	862 (n=4)	678 (n=4)	975 (n=4)		1258 (n=4)	663 (n=4)	1158 (n=4)

Table 8. The frequency of the 20 best advanced breeding lines participating in the 1984-1986 EPR and their yield range (in parenthesis).

Frequency and yield range (kg/ha)						
12	11	10	9	8	7	6
Black seeded (out of 15 experiments):						
LM 30074 (2577-728)	(2187-813 NAG 24) LM 20785 (2626-645)	(2823-834)		82 B VAN 39 LM 10363 (2254-1108) NAG 26 (2058-848) W 22-8 (1827-636)	LM 21132 (2786-858) LM 30063 (1856-904) LM 21135 (2535-712)	
Cream seeded (out of 22 experiments):						
	82 PVBZ 1783 (2503-523) EMGOPA 201 OURO (2364-426) ESAL 506 (2860-703) LM 21303-0 (2217-337)	ESAL 501 (2408-420)	L 11093 (1650-439) ESAL 507 (2612-874)	82 PVBZ 1901 (1723-379) A 254 (1961-635) A 300 (2102-482) ESAL 504 (2349-403)	82 PVBZ 1718 (2187-358) 82 PVBZ 1770 (2343-310) 82 PVMX 1637 (2049-341) 82 PVMX 1638 (2090-992) A 251 (2275-800) ESAL 505 (2537-324) LM 21306-0 (2110-747)	
Purple/pink seeded (out of 7 experiments)						
					LM 10092-0 (1850-585)	82 PVBZ 1838 (2142-748) BAT 41 (1927-907) ESAL 502 (1873-1035) LM 10348 (1597-923)

Table 9. Compositon of materials participating in the 3rd generation of EPR 1986-1988.

Institution	Black	Cream	Carioca	Red/purple	Total
CNPAF	18	27	13	13	71
ESAL	-	-	5	1	6
IAC*	1	1	1	1	1
CIAT	4	15	1	4	24
IAPAR	1	-	-	1	2
Univ. of Wisconsin	6	-	-	-	6
Elite checks	2	2	1	1	-
	(LM 30074)	(IPA 6)	(A 281)	(LM 10348)	
	(LM 21135)	(EMGOPA 201 OURO)			
Local checks	4	4	4	4	-
Total checks	36	49	25	25	-

* IAC Carioca is used in all EPR seed colors.

Table 10. Mean production (kg/ha) and disease scores of 20 lines or cultivars of black beans obtained in the "dry" season. EMGOPA 1986 (GO/DF).

Line/cultivar	Goiania	Bac.[a]	Anapolis	Pirenopolis	Itapuranga	Firminopolis	Bac.*	ALS*	COOPA/DF	Mean
LM 30074	1808abc[b]	7	487a	2182a	843ab	848a	4	2	646a	1136a
ICA COL 10103	1641abc	6	676a	2000a	831ab	933a	6	3	719a	1133a
BAT 1647	2134a	7	608a	1689a	923ab	823a	4	-	542a	1120a
Porrillo S.	2137a	7	520a	1848a	907ab	837a	6	5	427a	1112ab
LM 21132	1900ab	7	604a	1939a	1005ab	752a	7	3	458a	1110ab
EMGOPA 201-Ouro	1572abc	8	513a	2036a	928ab	879a	8	1	656a	1097ab
Carioca	1666abc	7	540a	1771a	948ab	770a	6	5	646a	1056ab
BAT 431	1660abc	7	510a	2144a	817ab	811a	7	3	385a	1055ab
Rico 23	1613abc	6	573a	1966a	952ab	692a	7	5	448a	1041ab
LM 20720	1686abc	6	574a	1842a	897ab	797a	3	4	437a	1039ab
LM 21124	1493abc	6	631a	1793a	960ab	707a	5	3	510a	1016abc
Rico 1735	1588abc	8	490a	1920a	955ab	638a	6	2	500a	1015abc
LM 30016	1566abc	6	531a	1792a	925ab	759a	7	3	406a	996abc
SPB-1	1419abc	6	555a	1875a	790ab	973a	5	2	365a	996abc
BAT 67	1041abc	7	481a	1999a	1169a	792a	7	5	469a	992abc
FT 83 120	1241abc	6	632a	1551a	935ab	757a	5	4	406a	920abc
BAT 451	1100abc	7	501a	1981a	769b	825a	8	4	344a	920abc
FT 83 160	839 bc	6	615a	1653a	883ab	843a	6	4	490a	887abc
LM 10401	1232abc	6	458a	1566a	646 b	800a	4	5	375a	840 bc
Rio Tibagi	647 c	6	389a	1568a	789ab	663a	5	4	500a	763 c
Mean	1499		544	1856	894	796			486	1013
L.S.D. (5%)	1207		344	981	383	403			394	272
C.V. (%)	25.9		20.4	17.0	13.8	16.3			26.1	22.5

[a] Disease scoring: Bac. = Bacterial blight; ALS = Angular leaf spot. Scoring is 1 - 9 where 1 = symptomless and 9 = plant death.

[b] Means followed by the same letters do not differ significantly at the level of 5% probability by Tukey's test.

Table 11. Mean production (kg/ha) and disease scores of 20 lines/cultivars of colored beans obtained in the "dry" season. EMGOPA 1986 (GO/DF).

Line/cultivar	Goiania	Bac.[a]	Anapolis	Pirenopolis	Itapuranga	Firminopolis	Bac.	ALS	COOPA/DF	Mean
Carioca	1413a[b]	7	422a	2121a	1055ab	919ab	7	6	458a	1065a
ESAL 502	1373a	7	471a	1987ab	1115ab	817ab	7	5	583a	1058ab
XAN 57	1513a	7	505a	1981ab	1017ab	770ab	7	-	448a	1039ab
LM 10348	1757a	7	536a	1785abc	844abc	850ab	7	3	365a	1023ab
ESAL 503	1479a	7	550a	1076abc	1133a	709ab	8	-	396a	995ab
Roxao RG	1471a	7	755a	1045abc	844abc	1071a	6	5	312a	976ab
BAT 614	1692a	6	540a	1599abc	925abc	712ab	7	-	385a	975ab
EMGOPA 201-Ouro	1238a	8	630a	1617abc	1019ab	813ab	8	-	510a	971ab
LM 10092	1448a	8	467a	1645abc	984ab	803ab	6	5	458a	967ab
BAT 1458	1473a	5	532a	1482abc	922abc	809ab	7	-	396a	936ab
XAN 37	1593a	5	583a	1132abc	978ab	792ab	6	-	458a	923abc
Parana 1	1301a	7	695a	1213abc	981ab	681 b	9	7	490a	893abc
BAT 363	1150a	7	786a	1427abc	866abc	694ab	8	4	354a	880abc
LM 10089	987a	8	561a	1637abc	947ab	696ab	7	5	406a	872abc
LM 30068	1194a	6	677a	1561abc	785bc	768ab	7	4	240a	870abc
82 PVBZ 1838	1538a	7	466a	1350abc	785bc	682ab	7	3	333a	859abc
Rosinha G 2	1201a	8	563a	1112bc	917abc	842ab	9	7	469a	851abc
LM 30013-0	1011a	8	471a	1459abc	881abc	747ab	7	3	375a	824 bc
FT 84292	1141a	7	510a	1107bc	927abc	874ab	7	5	385a	824 bc
CNF 10	1143a	7	346a	860c	606c	691ab	8	5	479a	687 bc
Mean	1356		553	1509	927	787			415	924
L.S.D. (5%)	805		530	1002	338	389			345	105
C.V. (%)	19.1		30.9	21.4	11.7	15.9			26.8	21.7

[a] Disease scoring: Bac. = Bacterial blight ALS = Angular leaf spot Scoring 1 - 9 where 1 = symptomless and 9 = plant death.

[b] Means followed by the same letters do not differ significantly between themselves at the level of 5% probability by Tukey's test.

Table 12. State trials conducted by PESAGRO during 1985/86.

Identification	Wet Season 1985/86 Campos	Wet Season 1985/86 Itaocara	Wet Season 1985/86 Natividad	Dry Season 1986 Campos	Dry Season 1986 Bom Jesus do Itabapoana	Mean
	kg/ha					
1. PV 99 N	1826	473	668	1143	2040	1230
2. LM 30063	1633	520	799	850	2260	1212
3. A 222	1640	433	784	1023	1766	1129
4. EMP 84	1700	433	527	890	1900	1090
5. LM 21124	1603	420	735	763	1860	1076
6. NAG 24	1600	386	464	910	1873	1047
7. LM 30036	1446	340	345	833	2013	995
8. LM 10363	1600	333	299	890	1786	982
9. W 22-3	1366	466	297	903	1873	981
10. LM 20816	1396	366	326	686	1966	948
11. W 22-8	1286	313	426	796	1733	911
12. LM 00574	1413	200	92	913	1833	890
13. 82 B VAN 74	1093	366	378	-	-	612
14. NAG 87	953	500	219	-	-	557
15. W 22-55	980	333	340	-	-	551
CHECKS						
1. BR 2-Grande Rio	1906	433	567	1220	1926	1210
2. BR 1-Xodo	1786	453	446	1200	1873	1152
3. BR 3-Ipanema	1406	666	469	930	1826	1059
4. Capixaba	1953	526	680	-	-	1053
5. Porrillo Sintetico	1706	566	498	-	-	923

Table 13. The selected lines for state trials of PESAGRO from EPR 1984/86.

	IDENT.	Wet season 84/85	Dry season 85	Wet season 85/86	Dry season 86	Mean
		kg/ha				
1.	NAG 24	1946	2038	2033	992	1752
2.	LM 30036	1237	2073	2283	1066	1664
3.	NAG 15	1473	1885	2033	1066	1614
4.	LM 30063	1661	1825	1800	1125	1602
5.	LM 10360	956	1921	2100	1316	1573
6.	W 22-55	1826	1861	1425	1083	1548
7.	A 231	1486	1833	1558	1283	1540
8.	LM 21124	1297	2088	1600	1150	1533
9.	82 B VAN 39	1505	1581	1866	1158	1527
10.	W 22-3	1898	1725	1633	466	1511
11.	DOR 218	1393	1720	1466	1458	1509
12.	W 22-8	1452	2080	1816	683	1507
13.	LM 10363	1384	2006	1966	656	1503

Table 14. The best early maturing lines selected in PESAGRO in Campos in 1986.

CNF germ-plasm number	Identification	Seed color	Yield (kg/ha)	Days to maturity	Yield (kg/day)
1. CNF 3268	82 PVMX 1554	Cream	2479	74	33.5
2. CNF 3451	BAT 304	Black	2208	74	29.8
3. CNF 0298	-	Black	2104	74	28.4
4. CNF 0302	-	Black	2083	74	28.2
5. CNF 830078	F.Preto da Linha	Black	2002	74	27.9
6. CNF 3141	Branco Argentina	White	2000	74	27.0
7. CNF 830077	F.Preto Rio Tigre	Black	1979	74	26.7
8. CNF 3936	A 460	Carioca	1979	80	24.7
9. CNF 0299	-	Black	1916	74	25.9
10. CNF 4540	Huetar	Red	1791	74	24.2
11. CNF 3918	A 441	Carioca	1770	74	23.9
Checks					
Capixaba precoce		Black	1208	74	16.3
BR2-Grande Rio		Black	1416	74	19.1
60 days		Black	833	74	11.3

Table 15. In-state trials in Santa Catarina during the period 1985/86 for black and cream seeded materials. Yield and disease scoring.

					Disease Scoring [a]			
Identification	Chapeco	Ituporanga	San Joaquim	Average Yield	Anthracnose	Bacterial Blight	Rust	Angular leaf spot
Black Seed Color:								
FT 83 120	2539ab	2314a	2608ab	2487	1	3.0	3.0	1
EMPASC 201	2607a	2006b	2838ab	2484	1	3.0	2.5	3
BAT 75	2651a	1665cd	2297b	2204	1	3.0	5.0	3
A 226	1978c	1722c	2912a	2204	1	3.0	2.3	1
PV 99N	2273b	1867bc	2359ab	2166	4	3.0	4.3	1
XAN 55	2345b	1818bc	2289bc	2151	1	3.0	4.0	1
BAT 1647	2689a	1828bc	1712d	2076	3	3.0	5.0	1
Rio Tibaji	2013c	2010b	1732cd	1918	5	3.0	5.0	3
RAI 76	2014c	1935bc	1752cd	1900	1	3.0	5.0	1
FT 85-25	2673a	1677cd	1244d	1865	1	3.0	5.0	1
Iguacu	2562ab	1599cd	1382d	1848	1	3.5	5.0	3
Turrialba 4	1912c	1492cd	1562d	1655	4	3.0	4.5	3
BAT 1470	1889c	1505cd	1379d	1591	1	5.0	4.0	3
Cream Seed Color:								
Carioca	2806a	2184a	2746a	2382	5	1.7	3.5	3
A 140	2482b	2105ab	2727a	2271	1	1.5	2.0	1
A 266	2356bc	1918bc	2256ab	2243	4	2.3	3.0	1
Parana 1	2345bc	1895bc	2162b	2134	5	3.0	2.5	3
Carioca 80	2084c	1721c	2155b	2180	1	3.0	5.0	3

[a] Disease scoring: 1 = symptomless
5 = very severe

[b] Means followed by the same letter within a column do not differ at the p = .05 level

Table 16. In web blight nursery at UEPAE Porto Velho/Rondonia lines with lowest % of disease incidence on leaves. No yield data is available from this nursery.

Identification	Incidence (%)
BAT 1614	40
G 3645	50
A 154	50
A 156	50
BAT 1298	50
BAT 1560	50
A 237	60
Porrillo Sintetico	60
A 216	60
BAT 450	60
A 301	60
BAT 160	60
A 381	60
BAT 256	60
A 286	60
BAT 1374	60
BAT 1447	60
Centa Izalco	60
Xan 90	60
A 296	60
A 294	60
EMP 117	60
BAT 1297	70
Chorotega	80
Centa Zumal	80
Negro Huasteco	80
Talamanca	90
Huetar	90
BAT 1295	90
Acasia 4	95
Revolucion 81	100
BAT 477 (drought resistant)	100
A 295 EMGOPA 201 Ouro	100

Carioca check varied between 80-100.

Table 17. Average yield of the best lines under non-stress and P stress conditions with their response factors and additional P requirements to reach maximum yield.

Identification	Yield Non-stress	Yield P-stress	Response factor alpha	Additional P-require. to reach max. yield
Carioca type:	kg/ha	kg/ha		
1. BZ 3836-1	1275	1085	1.58	34.8
2. BZ 3836-2	1230	820	3.42	93.5
3. MX 2759-20	1210	720	4.08	102.9
4. BZ 3815-1	1190	765	3.54	105.9
5. BZ 2384-20	1185	670	4.29	109.5
6. BZ 2511-5	1145	850	2.46	117.8
7. A 251	1140	985	1.29	120.1
8. BZ 2384-19	1125	710	3.46	124.2
9. BZ 2511-3	1120	740	3.17	126.1
10. MX 2184-1	1110	960	1.25	144.0
Checks				
A 252	1105	980	1.04	153.8
A 283	1020	800	1.83	185.7
Carioca	890	800	0.75	453.3
Cream seeded:	kg/ha	kg/ha		
1. ESAL 506	1750	1070	5.67	44.0
2. 82 PVBZ 1770	1400	1220	1.50	66.6
3. BZ 2231-11	1455	1080	3.12	76.9
4. 82 PVBZ 1785	1480	820	5.50	90.9
5. BZ 2518-1	1415	810	5.04	101.1
6. 82 PVBZ 1901	1335	1145	1.58	110.7
7. BZ 1031-1	1335	1100	1.96	112.2
8. BZ 3919-2	1350	680	5.58	114.6
9. BZ 4578-1	1340	745	4.96	115.9
10. BAT 93	1320	670	5.42	119.9
Checks				
G 4000	1080	870	1.75	257.1
G 5054	1065	670	3.29	197.5
G 5059	870	750	1.00	570.0
IPA 74-19	860	680	1.50	426.6

cont.

Table 17 cont.

Identification	Yield Non-stress	Yield P-stress	Response factor alpha	Additional P-require. to reach max. yield
Black seeded:	kg/ha			
1. Xodo	1405	1180	1.88	47.8
2. LM 30629	1450	825	5.21	85.4
3. CNF 480	1400	940	3.83	86.1
4. W 22-14	1385	935	3.75	89.3
5. LM 21135	1345	1045	2.50	90.0
6. LM 21132	1375	935	3.67	91.2
7. LM 21124	1345	1015	2.75	92.7
8. LM 10363	1340	1015	2.71	94.0
9. W 20-9	1375	850	4.38	95.8
10. 84 VAN-60	1300	1015	2.38	107.1
Checks				
ICA Pijao	1095	610	4.04	103.3
ICTA Jutiapan	955	700	2.12	268.8
Puebla 152	900	810	0.75	613.3
Rio Tibaji	835	745	0.75	700.0
Purple seeded:	kg/ha			
1. MX 1418-1	1755	1405	2.92	42.8
2. MX 2709-24	1510	1220	2.42	128.0
3. TY 3350-2	1415	940	3.96	148.9
4. TY 3350-3	1440	1200	2.00	165.0
5. TY 3364-9	1220	610	5.08	181.1
6. TY 3361-2	1365	1060	2.54	185.0
7. LM 10348	1330	970	3.00	186.6
8. MX 1418-2	1360	1070	2.42	190.0
9. ESAL 503	1190	665	4.38	197.4
10. TY 3361-6	1335	1060	2.29	205.2
Checks				
BAT 41	830	720	0.92	880.4
Rosinha G2	510	425	0.71	1556.3
CNF 10	510	460	0.42	2547.6

Table 18. Root length (cm) and relative root length (%) at five different depths of bean grown in Rhizoctron of Univ. Federal do Parana in 1986.

Depth in cm	Carioca cm	Carioca %	Rosinha 62 cm	Rosinha 62 %	A 283 cm	A 283 %	Puebla 152 cm	Puebla 152 %	CNF 10 cm	CNF 10 %	A 143 cm	A 143 %	Total cm	Total %
0 - 20	143.5	40	147.4	43	135.2	60	125.1	43	83.0	64	52.3	48	686.5	47
21 - 40	102.1	28	119.5	35	65.5	29	73.8	25	38.5	30	56.2	52	455.6	31
41 - 60	73.7	21	49.4	14	23.9	10	87.7	30	7.5	6	0.8	-	243.0	17
61 - 80	38.8	10	16.5	5	-	-	8.7	3	-	-	-	-	64.0	4
81 - 100	0.9	0	7.5	2	-	-	-	-	-	-	-	-	8.4	1
Total	359.1		340.3		225.6		295.3		129.0		109.3		1457.5	

Table 19. Bean yield (kg/ha) grown under different water tables at CNPAF - Palmital experimental station, 1986.

Variety	Average depth of water table (in cm) 6.00	6.95	7.90	8.85	9.80	10.75	11.70	Average
Emgopa 201-Ouro	225	308	325	438	563	930	1925	673
Carioca	168	213	295	513	588	1418	1770	709
BAT 67	70	163	405	405	1058	1275	1595	710
AVERAGE	154	228	342	452	736	1208	1763	697

LSD 5% VAR. = 134 kg/ha
LSD 5% Depth of Water table = 108 kg/ha
C.V. = 21.3%

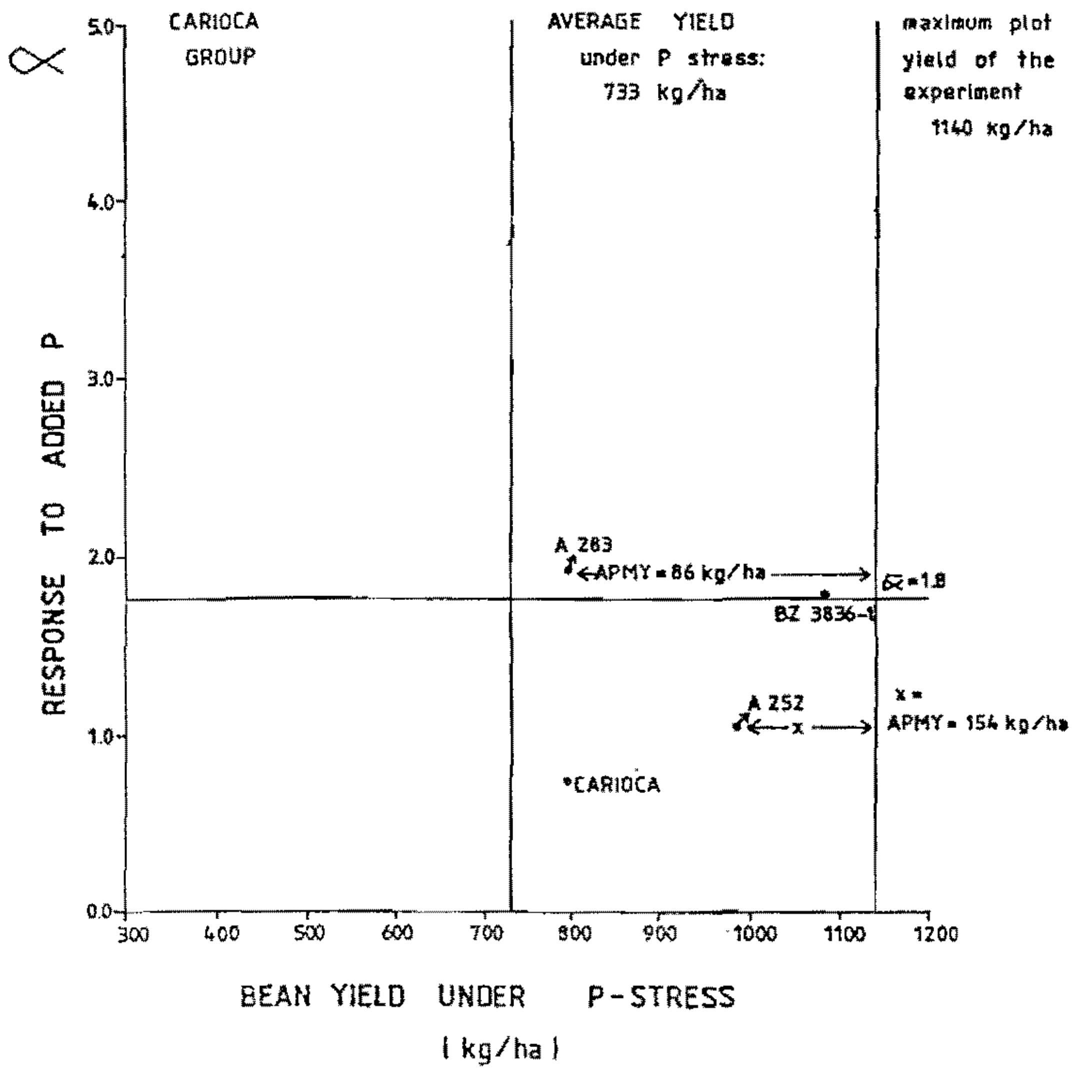


Figure 1. Evaluation of bean efficiency in using low soil phosphorus.

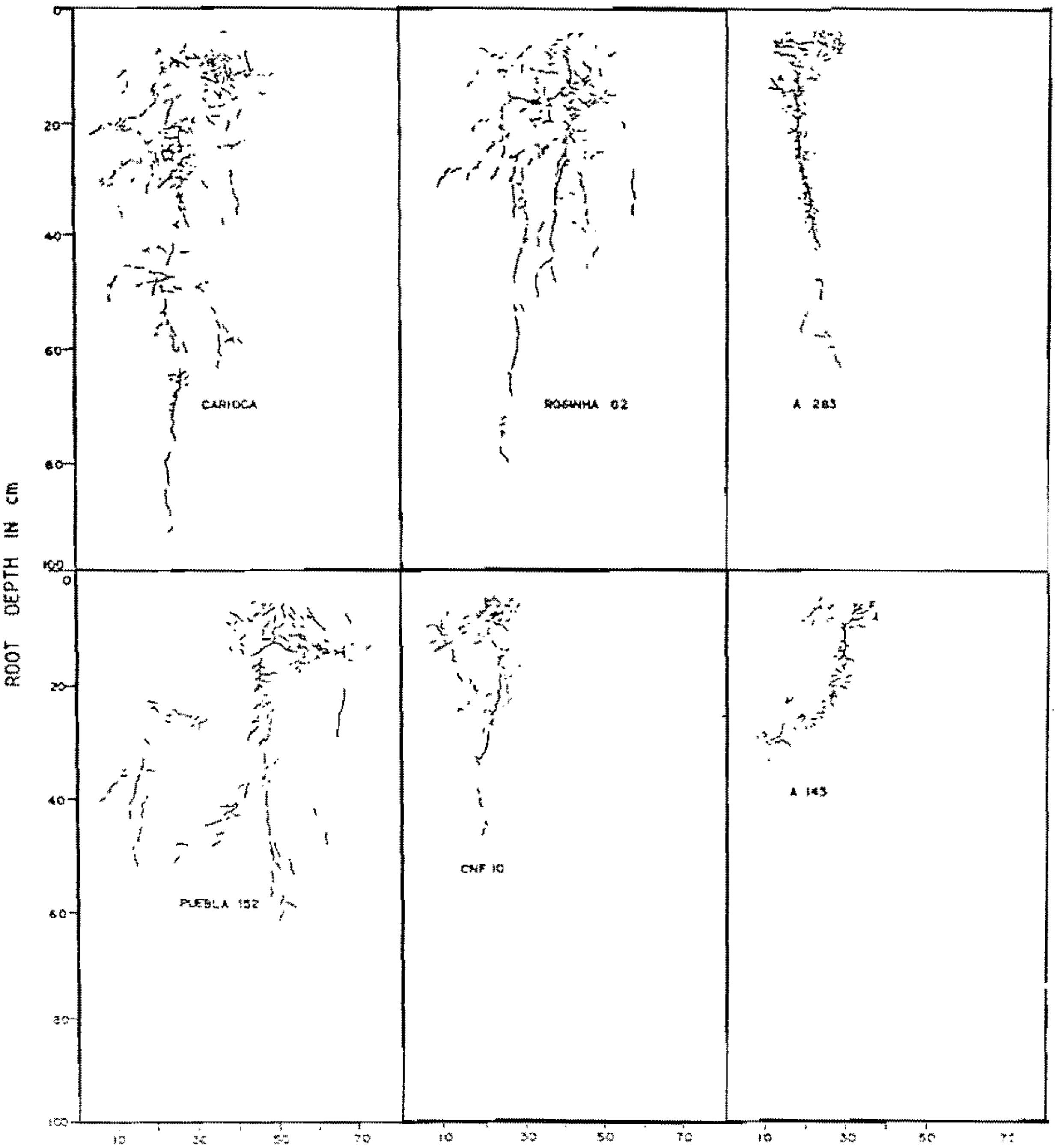


Figure 2. Rooting pattern of six different cultivars growing in rhizoctron of University Federal do Parana.

3. Peru

The objective of the three and one-half year old project in Peru, is to increase the production and consumption of beans in that area. In 1986 the project concentrated on three principle activities: genetic improvement, seed production and scientific training.

Advances in genetic improvement

The most significant advances in the coastal region consisted of the introduction of 35 advanced Canario type, BCMV-resistant bean lines. These lines are very similar in grain type to the traditional bean grown in that area, canario Divex 8130. These lines, together with CIFAC 1277, were evaluated in on-farm trials to determine which to release officially.

With support provided by the Peruvian universities in conjunction with INIPA, a new bean variety called "Panamito Molinero" was released in 1986. This is the first variety to be released, that is suitable for summer planting in the central coast area.

The best advanced bean lines for the mountainous areas continued to be selected for their productivity, and resistance to halo blight and anthracnose. Six newly selected lines formed the basis for the second trials known as "uniform yield trials for climbing beans for the sierras-1986", and nine lines were tested in the "uniform yield trials for bush beans for the sierras-1986". These trials were distributed for planting to 11 regional centers or CIPAs throughout the country.

No bean lines showing tolerance to web blight were selected for planting in the selva this year. However, a new variety of cowpea called "San Roque" was officially released for the Iquitos region.

Seed production

The production of basic bean seed was promoted in four principal regions of Peru, and more than 150 hectares were planted (Table 1). Seed was produced in farmers' fields by contract with CIPAs or regional centers.

Table 1. Principal areas of Peru promoting bean seed production.

Departament	Production zones	Varieties	Ha/planted
Lambayeque	various	Bayo Florida	
		Blanco Chancay	100
Arequipa	Camana, Majes	Canario Corriente	36
Cajamarca	various	Gloriabamba	30
ICA	Valle de Chincha	Canarios and Whites	25

Training

Six INIPA scientists working on beans participated in training courses given at CIAT, and others took courses in Peru. Courses in Peru were conducted at the International Potato Center (CIP), and comprised the third and last phase of training called "Postgraduate Intensive Course I for On-Farm Bean Research in Peru". This course has been conducted in production zones of Cajamarca since February 1985, and has provided training for 24 scientists.

Future plans

This report terminates the collaborative bean project with Peru. A project called PROCIANDINO will begin in 1987, and will include Venezuela, Colombia, Ecuador and Bolivia in addition to Peru.

CIAT's Bean Program will be working closely with the PROCIANDINO project financed by the Interamerican Development Bank.

4. Mexican Highlands

At the beginning of 1986, four trials each comprising 45 segregated populations were sent to Mexico, to be planted with four checks and two replications in two different locations. The objective was to further decentralize the genetic improvement process, by facilitating selection and evaluations in early generations under conditions which combine specific adaptation with resistance to local diseases. It is hoped that this method will advance bean research more quickly and concretely than previous management methods. At the same time, crosses made in 1985 were advanced at CIAT. In accordance with the new program strategy, these early populations were planted at CIAT/Palmira in replicated yield trials. The objective was to find the highest yield potentials under conditions of high technological inputs. The 850 populations planted in Palmira in 1986 under these conditions, will form the source of future lines.

5. Argentina and West Asia

In December of 1985, six sets of white lines from the VAPA 86 CIAT nursery were sent to three institutions in Argentina (INTA, EEAOC, and Rancho Las Cañas), to be planted in various localities in February 1986. The VAPA 86 nursery comprises 520 entries, including the best large seeded lines as well as small and medium seeded lines. Each line was selected for specific characters, and the next phase will include yield trials under various conditions. In addition, CIAT received a group of lines which had performed very well in Argentina, and with the help of two scientists visiting CIAT for three months, an IBYAN was developed with 16 entries that will be planted in four locations within Argentina in 1987. This will facilitate rapid advancement of the best performing lines in VAPA. EEAOC, in accordance with results obtained from their regional trials program, decided to release three white seeded lines: TUC 122 (small seeded); TUC 27 (medium seeded); and TUC 56 (large seeded). Two other accessions, PVAD 1111 (red seeded), and TUC 157 (black bean) were included. INTA has requested 48 new crosses from CIAT, (which can perform similarly to early lines from VAPA), to be tested in cool areas for rust resistance, and in hot areas for resistance to bacterial blights and white fly. These crosses will be begun in CIAT in 1987. With the help of two visiting scientists, 18 segregating populations were selected to be planted by INTA and EEAOC in the first season of 1987. These populations will allow selections to be made under local conditions.

A similar nursery called WANABAN 86 was sent to various regions of Turkey, Bulgaria, Spain, Portugal, Iran and Tunisia in April, 1986. The number of entries for these countries ranges from 30-400 for each trial. Little information has been received to date on the results of these trials.

Crossing activities continue at CIAT for various grain types; last year saw the initiation of crossing in Dermason, Great Northern and Bolita lines. All of these populations will be planted in CIAT/Palmira in 1987. In December 1985, 55 segregating populations including parents of local grain types, were sent to Turkey. These populations will be planted there in 1987, to provide adequate selection under local conditions for Turkey's genetic improvement program.

Earliness

This season's crossings include early maturing parents like G 2883, G 3017, and others. These are crosses made for different commercial grain types. Following the same strategy mentioned earlier, 240 populations were selected from 300 segregated populations in Palmira. These populations were planted in Quilichao in 1986. Further selections were made and 130 populations were planted at Popayan in December 1986. Individual selection will be carried out and it is hoped this will produce a large quantity of early maturing selections to be evaluated in 1987.

Drought

Sixty-seven segregating populations were planted in Palmira for this project. They are to be evaluated in the dry season (December 1986-February 1987). These populations were planted under moderate drought stress, receiving irrigation only twice throughout the growth cycle. Seed was produced from 66 diallel crosses made between 12 drought tolerant lines, for a genetic study of this characteristic.

Anthracnose

A new evaluation of reactions to anthracnose (*Colletotrichum lindemuthianum*) was conducted in Popayan with available germplasm from the germplasm bank (16,500 accessions).

Unfortunately, weather conditions, adaptation problems, and root rot prevented a thorough study, and results were gathered from only 54% of the accessions (8762 accessions). Of these, 4596 showed resistance or intermediate resistance to anthracnose, and 4166 were susceptible. However, 51 segregating populations which combined sources of resistance with other favorable characteristics, were advanced.

Table 1. Advanced populations 1986. Bean Improvement II.

Zone or Project	Palmira	Quilichao	Popayan
Brazil	736 (March)	589 (August)	316 (December)
Mexico	850 (December)		
Drought	67 (December)		
Earliness	300 (March)	240 (August)	130 (December)
Anthracnose			
TOTAL	1953	829	497

6. Andean Zone

Colombia

In 1985 three new cultivars were released as a result of collaborative research between ICA and CIAT ('convenio ICA-CIAT'). These were Frijolica 0-3.1 (bush bean for highlands), Frijolica 0-3.2 (climbing bean for highlands) and Frijolica LS-3.3 (climbing bean for highlands). Quantities of basic seed produced at the ICA stations CRI Obonuco and CRI La Selva are shown in Table 1.

Antioquia: At CRI La Selva, 190 new advanced lines of climbing beans were coded. A set of 32 lines has been selected on the basis of yield, disease resistance and grain type, and these are currently in an advanced yield trial under low and high fertility, and will form the basis for a regional trial for altitudes between 1800 and 2600 m in Colombia in 1987. Yield gains continue to be made over cultivars released to date. As well as improvements in the Cargamanto type, many lines are now available with the Radical grain type. The first cultivar released in the collaborative program, ICA Llanogrande, has been an important parent in the new generation of advanced lines, as a source of improved yield and anthracnose resistance. Although improved levels of *Ascochyta* resistance are gradually being obtained, progress with resistance to this pathogen is slower. In fungicide trials, the best control of *Ascochyta* has been obtained with Clorotalonil (1.25 g active ingredient/liter) applied weekly from two weeks before flowering to two weeks after flowering.

Regional trials with bush beans were conducted in 20 locations in Antioquia. The best lines were PVA 476, PVA 7 and PVA 698, which will pass to confirmation trials for possible variety release.

Nariño: At CRI Obonuco, 10 advanced climbing bean lines were planted in regional trials intercropped with maize in Ipiales, Contadero and Cordoba. The most promising lines for possible variety release are AND 53, known also as V-8012-43, and ZAV 7, known also as TIB 30-42. These are both resistant to rust and anthracnose, and yielded on average 180% and 158% more than the local cultivar Mortiño in four locations. Results obtained initially on the experiment station, indicating that yield could be increased with the new cultivars by reducing the distance between hills of beans and maize, have been confirmed in on-farm trials. The distance recommended for Frijolica 0-3.2 is 0.80 m x 1 m between hills, allowing increased yields of both bean and maize.

Regional trials with bush beans in Nariño were planted in El Tambo and Funes. In El Tambo (dry, 1250 m altitude), the best new lines were AND 359, ICA 15551 and AND 311, with yields 28% to 42% greater than Nima (local cultivar). In Funes the best new lines were PVA 3043, AFR 198 and PVA 3038, yielding 19% better on average than Argentino (local cultivar).

Coffee Region: In 1985 a regional bush bean trial consisting of seven bean lines, plus a local check, was organized in collaboration with

ICA. The bean lines were chosen on the basis of yield data from previous regional nurseries. The trials were planted by agronomists from FEDECAFE, CVC, FES, and ICA in the medium altitude areas of Colombia. Calima, the standard commercial cultivar, had the lowest overall yield, followed by PVA 916 and the local cultivar, which varied according to region (Table 2). Two small red mottle bean lines, PAI 29 and PAI 92, were superior to the other lines in overall yield. The disadvantage of these lines, however, is their small seed size. Their high yields may, nevertheless, make them attractive for farmers in certain areas, especially those less orientated towards the major markets. Bean lines A 36 and A 486 had yields greater than the local cultivar and Calima and an acceptable grain size and color. These lines are presently being grown in large demonstration plots throughout the country for possible variety releases.

The yield trial in many areas of Colombia was attacked by web blight. Only PAI 29 and PAI 92 showed resistance, which may have contributed to their superior yields. Because of the importance of this disease in many of the bean producing areas, a special Observation Nursery was formed in 1986 to determine whether any of the elite CIAT and ICA advanced lines are resistant. The nursery consists of 219 lines of commercially acceptable grain type and has been planted in six locations. The best materials from this nursery will form the basis for future regional yield trials.

Table 1. Quantities of basic and certified seed produced in 1985/86 of three new cultivars released in Colombia.

Cultivar	Basic Seed kg	Certified Seed kg
Frijolica 0-3.1	1080	-
Frijolica 0-3.2	1106	-
Frijolica LS-3.3	1000	2455

Table 2. Regional bush bean yield trial in Colombia, 1985-1986

	LOCATION																	
Bean Lines	Pitalito 86A	Pitalito 85B	Pitalito 85B	Garzon 85B	Timaná 85B	La Plata 85B	Consacá 85B	Restrepo 85B	El Aguila 85B	Ibague 85B	Aranzazu 85B	Manizales 85B	Chinchina 85B	Viota 85B	Cocorná 85B	Mean	Seed wet g/100	Seed Color
A 36	1124[1]	1393	1045	996	1121	1215	1207	691	1229	909	675	1387	1221	988	1866	1138	47	Red mottled
A 486	1077	799	1667	1530	647	631	1212	1262	1613	1135	1170	1313	1221	1708	1166	1210	46	Cream mottled
PVA 916	1016	897	1081	1217	373	661	1216	824	1536	1676	1344	672	1362	1146	966	1066	46	Red mottled
PVA 1261	1147	1177	1332	1119	403	371	1112	1036	732	1561	1198	1566	1221	1123	1256	1090	46	Red mottled
Calima	724	824	1963	1238	388	440	1291	582	1152	1135	1274	641	1157	1168	622	973	55	Red mottled
PAI 29	1986	1858	997	1367	2587	3038	1454	2146	1638	1276	1325	2096	964	1376	1294	1694	30	Red mottled
PAI 92	1801	1844	846	1534	3450	2507	1420	2528	1229	1135	1348	867	1414	1780	1478	1679	23	Red mottled
Local variety	1062	1138	1002	943	964	1078	1024	867	804	1107	1608	1394	1374	644	1292	1087	40-55	Variable
Significance level	**	NS	*	NS	**	**	**	**	NS	**	NS	**	NS	NS	NS			
Dept.	Huila	Huila	Huila	Huila	Huila	Huila	Nariño	Valle	Valle	Tolima	Caldas	Caldas	Caldas	Cundinamarca	Antioquia			
Altitud	1350	1350	1458	-	-	-	1500	1450	1700	1250	1950	-			1450			
Precipt.	2000	2000	1600	-	-	-	1390	1200	1800	1875	2500	-		-	2500			
Local Variety	Nima	Nima	Nima	Nima	Nima	Nima	Nima	Calima	Sangretoro	Algarroba	Uribe Rosado	Tone	Tone	-	Chiquita Roja			

**, * indicate significant differences among means within a column at P=0.05 on P=0.01 level, respectively

1 the individual means were adjusted according to the overall mean of the locality and the grand mean of all the trials.

7. Africa

a. Great Lakes Region

The Great Lakes Regional Bean Program, financed by the Swiss government (SDC), serves the Great Lakes Region of central Africa which includes Burundi, Rwanda, and Zaire. The program works with the region's national agricultural research institutions: Institut des Sciences Agronomiques du Burundi (ISABU); Institut des Sciences Agronomiques du Rwanda (ISAR); and with both Zaire's Programme National Legumineuses (PNL) and its Institut National des Etudes et Recherches Agricoles (INERA). The report which follows represents the work of these national research institutions in collaboration with CIAT, and with various development and agricultural projects.

Regional collaboration and training

The region's national programs currently collaborate in several region-wide research activities such as the Pépiniére Régionale d'Evaluation de Résistance (PRER), the Pépiniére Régionale d'Evaluation de Lignées Avancées de l'Afrique Centrale (PRELAAC), the regional advanced yield trials, and regional subprojects. The PRELAAC program has just begun and is described in the Varietal Development section of this report.

The first regional subprojects were initiated this year. National research programs take responsibility for specific research topics of regional importance. These subprojects are partially financed with regional funds. The techniques, varieties and information obtained are shared among the programs. Progress made on each subject is reported at regional bean research meetings.

Subprojects initiated so far focus on angular leaf spot (ALS), common bacterial blight, halo blight and bean fly. The ALS project, managed by PNAL at Mulungu, Zaire, will study yield reductions caused by this disease, and identify and develop better adapted sources of resistance. In Burundi, ISABU has recently initiated subprojects on common bacterial blight, halo blight, and on control methods for bean fly. Additional subprojects are being planned.

In addition to collaboration among national programs, close collaboration with regional agricultural and development projects has been critical in increasing efficiency of research and subsequent information diffusion. A major event this year was the establishment of a link with the important bean production region of North Kivu, Zaire, through beginning collaboration with two development and seed production projects located in the region. These projects are CAPSA (Centre d'Adaptation et de Production de Semences Améligrées), financed by Canadian aid, and CBK (Communauté Baptiste au Kivu) which has a strong rural development emphasis. Collaboration with these projects, in diagnostic research and multilocation, and on-farm trials, promises to facilitate the transfer of technology from PNL (based in southern Kivu) to this important production region.

The second annual regional bean research conference was held at Bukavu, Zaire, May 19-24. This was jointly organized by the CIAT Regional Program and the Institut de Recherche Agronomique et Zootechnique (IRAZ), a regional agricultural institute of the Great Lakes Region. Some 34 presentations were made on various aspects of bean research. The seminar strongly reinforced collaboration with Zaire.

In December 1985, the CIAT Program participated in a three-day bean research and extension workshop held by ISAR at Rubona. The objective of the workshop was to update agricultural and development projects in Rwanda on legume research carried out by the institute. The workshop generated further interest in projects focusing on carrying out multilocation and on-farm trials in cooperation with ISAR.

A stronger emphasis was placed on training this year. The program's first technical training workshop was held at Gisenyi, Rwanda, April 19-24, with participants from Zaire and Rwanda. An important objective of this workshop was to train technicians from North Kivu, Zaire, to manage trials and surveys. Other training activities included two bean disease and insect workshops at Rwerere, Rwanda, May 26-29 and July 7-9, in collaboration with ISAR, and a USAID farming systems project called FSIP. Additionally, an on-farm research workshop at Butare, Rwanda, was organized with CIMMYT and ISAR, August 26-29. In addition to attending workshops, inter-program visits by national research staff were strongly encouraged. For example, two separate visits to Rwanda were made by neighboring Ugandan national bean program scientists for short-term training in on-farm research, as well as to obtain germplasm for their program.

Varietal development and evaluation

A large quantity of germplasm continued to be introduced to the region during 1986 (Table 1). Advanced breeding lines were introduced as potential new varieties for the region and/or as sources of resistance to the limiting production factors of the Great Lakes area, with a special emphasis on disease resistance. Together with locally collected germplasm, the introduced germplasm forms an excellent basis for the varietal development programs.

Local germplasm was collected throughout the region in 1986 with the support of IBPGR and USAID. Since the initiation of the CIAT regional program, more than 600 local varieties and varietal mixtures from these and other collections have been quarantined in Europe, and sent to CIAT for inclusion in the CIAT germplasm collection. Germplasm quarantine in Europe is handled by the National Vegetable Research Station, Wellesbourne, England, and Gembloux University, Belgium. Shipment of this germplasm to CIAT has allowed crosses to be made at CIAT between locally collected germplasm and other varieties developed or collected by CIAT. Many of the varietal crosses shipped back to the Great Lakes Region from CIAT now include local varieties as one of the parents.

A large proportion of germplasm is now introduced as segregating populations, and varietal development programs of the region are placing increasing emphasis on managing segregating populations as a source of new varieties. Large numbers of bush and climbing bean breeding lines, developed locally or introduced, are now passing through on-station varietal testing to on-farm evaluation.

Many promising bush and climbing bean varieties have been identified by the national programs. New promising bush varieties at advanced stages of evaluation in the region include the following:

From ISABU: PVA 1186, PVA 779, A 410, and locally developed varieties HM 5-5 and HM 21-7
From ISAR : PVA 1438, G 13671, G 11060, and a locally developed variety RWR 221
From PNL/ZAIRE: BAT 1297, and a locally collected variety Nakaja.

New promising climbing bean varieties were included in the regional climbing bean trial (Table 2).

Table 1. Germplasm originating at CIAT introduced and evaluated in the Great Lakes Region in 1986.

National Program		IBYAN yield trials	Advanced[b] lines	Segregating populations
ISABU	(Burundi)			
	1986 A[a]	0	329	45
	1986 B	1	338	61
ISAR	(Rwanda)			
	1986 A	1	1018	285
	1986 B	0	211	393
PNL	(Zaire)			
	1986 A	4	329	13
	1986 B	0	0	51
	TOTAL	6	2225	848

a · 1986 A: January harvest, 1986 B: June harvest
b Germplasm accessions from Latin America or breeding lines developed at CIAT.

Table 2. Results of Great Lakes regional advanced climbing bean trial, 1986.

Mulungu, Zaire (1730 MASL)	1986 A kg/ha	Mulungu, Zaire (1730 MASL)	1986 B kg/ha	Days/M[x]
G 2331	1391	Puebla Criolla	3083	113
G 2333	1219	ACV 8331	1913	113
G 685	1181	G 858	1900	114
Urunymba 3	921	G 685	1658	92
Puebla Criolla	849	Nain de Kyondo	1645	110
Nain de Kyondo	820	Mabayange	1570	111
ACV 8331	813	C 10	1463	111
G 858	805	G 2333	1350	110
Musale	726	G 2331	1325	110
Cuarentino-0817	714	Cuarentino-0817	1200	113
C 10	684	Musale	1083	110
Mabayange	678	Urunymba 3	925	111
Local Mixture	368	Local Mixture	-	
LSD. 05	368	LSD. 05	592	

Rwerere, Rwanda (2100 MASL)	1986 A kg/ha	Rwerere, Rwanda (2100 MASL)	1986 B kg/ha	Days/M
G 858	2240	G 858	1656	122
G 2331	1727	Local Mixture	1375	109
G 2333	1685	ACV 8331	1208	121
Urunymba 3	1248	Urunymba 3	1172	108
C 10	1218	C 10	1108	111
Cuarentino-0817	1135	Mabayange	1094	121
Local Mixture	1090	G 685	1070	113
Puebla Criolla	843	Cuarentino-0817	995	117
ACV 8331	788	G 2333	922	111
Nain de Kyondo	732	Nain de Kyondo	898	121
Mabayange	728	Musale	604	111
Musale	632	Puebla Criolla	518	121
LSD.05	458	LSD.05	519	

X = Days to maturiy

Some of these new varieties however, often have certain characteristics that limit their potential yield. For example, two high yielding varieties - Kirundo, released by ISABU, and Ikinyange (A 197), recently released by ISAR, - are very susceptible to halo blight and anthracnose, respectively. To incorporate resistance to these diseases, crosses are being made using as donor parents varieties identified as both resistant and well adapted in the region.

Introductions of varieties as sources of resistance to diseases of primary importance, such as angular leaf spot, anthracnose, Ascochyta and halo blight, continued as described in the CIAT Annual Report for 1985. Introductions are initially tested in disease specific nurseries for resistance and adaptation. Promising sources of resistance are later tested in the regional multilocational disease evaluation nursery (PRER) for stability of resistance.

Angular Leaf Spot

116 new varieties were tested and evaluated for resistance to ALS using the BALSIT (Bean ALS International Trial) by the national programs in 1986. The nursery was planted in southern Kivu, Zaire (Mulungu), and southern Rwanda (Rubona), where the disease is very prevalent. Results from two seasons have been pooled and analyzed, and best varieties are presented in Table 3. Highly significant differences (p=0.05) in ALS severity were found among the 116 varieties. Although there was no significant improvement in the level of resistance to ALS expressed by the new varieties in comparison to such established sources as A 240, there was an improvement in diversity in the new lines. More seed colors and sizes were available in adapted lines for breeding purposes and varietal selection. However, there are still no good sources of resistance in growth habit I and large seeded varieties.

Anthracnose

In Rwanda the national program draws primarily on the International Bean Anthracnose Trial (IBAT), and local germplasm collections for new potential sources of anthracnose resistance. Introductions are screened on-station at Rubona. Established resistant sources continued to be observed in the PRER, where varieties such as A 483, A 484, A 252 and others have been shown to be susceptible. New sources of resistance in 1986 are given in Table 4. These new sources were less well adapted than the local susceptible check. All anthracnose materials are also being tested by the Faculty of Agriculture at the National University of Rwanda, for resistance to regional pathotypes of anthracnose under controlled laboratory conditions. This will make rapid and accurate evaluations of the introduced sources possible.

Ascochyta Blight

Low levels of resistance to Ascochyta is presently available in P. vulgaris. In an effort to identify higher levels of resistance in the species, evaluation of the world germplasm collection has been initiated by CIAT in Colombia and the Great Lakes Regional Program. After initial screening in Colombia, lines will be sent to the GLR to allow evaluation on both continents for the prevailing pathotypes of the pathogen. These lines will also be evaluated under controlled environmental conditions in collaboration with the National University of Rwanda. Concurrently, the inheritance of Ascochyta resistance is also being investigated in collaboration with the national program.

Halo and Common Blight

The International Halo Blight Nursery (IBHBN) and the International Common Blight Nursery were evaluated by the national program of Burundi as part of a regional subproject. Diseases were evaluated in both inoculated screenhouse and field trials. Under uniform halo pressure, 91.2% of the 113 varieties of the IBHBN showed severity ratings between 1 and 3. Thirty-nine (39) varieties showed resistance against local races of Pseudomonas syringae p.v. phaseolicola.

Results of the evaluation of 127 varieties were not satisfactory, despite mechanical and spray inoculations. However, 40% of varieties showed pod infection and severity ratings of 7 and 8. The most susceptible lines tested included released varieties such as Kirundo and Calima.

Rust

The International Rust Nursery (IBRN) was evaluated in South Kivu and Bugasera, a low elevation region of Rwanda where rust (Uromyces appendiculatus) is considered locally important. Best adapted and symptomless lines in both locations were Guanajuato 10-A-5, Cuva 168-N, G 5712, Guerrero 6 and Turrialba, all black seeded varieties. A number of less well adapted, symptomless varieties, including, G 1098, Negro Jalpataqua, Guerrero 6, BAT 1426 and BAT 1427, had more acceptable seed colors.

BCMV

More emphasis was placed on screening of BCMV resistant materials and segregating populations in 1986. Approximately 100 parental materials and 250 populations were screened each season in the field. Materials such as BAC 122, previously thought to be resistant, showed mosaic symptoms in both seasons. However, most other established resistant lines such as BAN 6, BAT 1387 and VCB 81012 remained symptomless. In the future, further emphasis will be placed on BCMV resistance screening as well as identifying and assessing the distribution of regional BCMV strains.

Bean Fly

The Burundian national program has begun evaluating the Regional Bean Fly Resistance Nursery (RBFRN) and breeding lines for quantitative levels of resistance to bean fly. The predominant species of bean fly is Ophiomya spencerella. First season results were not conclusive since only a mild infestation of bean fly was found in the nursery. This research will continue next season. Research in the region using seed treatments with low toxicity chemicals for bean fly control was initiated this year. So far, bromophos, dialdrin, fenitrothion, lindane, propuxur, and trichlorfon have been tested in Burundi (ISABU Annual Report 1986, pp 174-176). The most effective of the chemicals tested is lindane: 25% a.i., used at 3 gm per kilogram seed before sowing.

PRELAAC

Late this year, a multiple site nursery composed of advanced breeding lines and varieties from the three national programs of the region was initiated (first planting October 1986) to obtain precise data on important varietal characteristics such as disease resistance. The principal objective is to provide this data to national varietal selection programs in order to increase the precision and efficiency of varietal selection.

The nursery complements the advanced yield trials of each national program which are not normally screened effectively for a large number of yield limitations. National programs are limited in their ability to screen for multiple diseases because of the difficulty of obtaining high pressure for several characters at a restricted number of sites. This nursery, called the PRELAAC (Pépiniére Régionale d'Evaluation de Lignées Avancées en de l'Afrique Centrale), is planted at several sites throughout the region, with one or two characters evaluated per site. Nurseries are managed to obtain high uniform pressure for the characters in question. Choice of sites is based on researcher expertise at a given location in conjunction with high natural pest or disease pressure.

The first PRELAAC includes a total of 187 varieties from the region's various advanced yield trials (essais préliminaires, essais comparatifs). Eight separate trials have been planted for the first season. Nine characters will be evaluated: bean fly, Ascochyta blight, angular leaf spot, rust, anthracnose, BCMV, halo blight, common blight and floury leaf spot. If necessary, additional evaluations may be made during the second season. Data will be compiled at the end of each year and distributed to national programs.

Culinary quality of advanced lines

Advanced lines from all three national programs in the region were evaluated for cooking time, water absorption and hardseed character (Table 5). A total of 211 different lines were evaluated over the two seasons from various locations. In almost all cases, significant differences were observed between varieties irrespective of environmental interactions (see the CIAT Annual Report for 1985, Environmental Influence Study). A summary of results for the regional trial can be found in the following section. All laboratory results for advanced trial materials were distributed to the respective national program breeders.

Advanced lines in 23 on-farm varietal trials in three communes of Rwanda were evaluated by farmers in 1986 A (first season), for leaf and pod culinary quality to estimate the relative importance of these characteristics in overall farmer acceptability. Results indicate that farmers can distinguish between varieties according to the culinary quality of leaves and pods, but that these characteristics are of less importance in determining overall farmer acceptability than, for example, yield, cooking time, taste, and time to maturity. For example, Ikinimba (a medium sized, black seeded variety), was the only variety with significantly more palatable leaves and pods than the local mixture. Nevertheless, farmers preferred to continue planting their local mixture instead of Ikinimba due to other more important negative characteristics, such as grain color, long cooking time and sprawling plant type. It was therefore decided not to include culinary quality of leaves and pods as a routine evaluation criteria.

Regional variety trials

The regional advanced bush bean varietal trial was planted during the year at several locations within the region. The trial included the four highest yielding varieties of 1985. New varieties from Rwanda and Zaire were included in the first season of 1986 (Sept. 85 planting) (Table 6). New varieties from Burundi were added for second season plantings (Table 7). Among new varietal entries, the varieties Nakaja, HM 5-1 and Ubusosera 6 were promising at several sites. Nain de Kyondo yields well at several sites but is possibly less promising because of its small white grain type and late maturity. In general, indeterminate growth habit III varieties had higher overall yields than less vigorous, growth habit I and II varieties. Though some varieties performed well over several sites, there was considerable variety by site interactions. Nain de Kyondo, for example, was highest yielding at Mulungu, but lowest yielding at Murongwe. Some varieties tend to be well adapted at a relatively restricted number of sites. A 410 performed well only at Moso. A 410 consistently yielded well in other ISABU trials at the same site and in the lower Ruzizi valley (950 MASL). A 410 did not however, yield well at Karama, (1300 MASL), the regional trial site most ecologically similar to Moso.

Variety by season interactions were significant at some sites during both 1986 and 1985. This is probably largely due to seasonal differences in disease pressure which is illustrated by the yields of Ikinyange (A 197), an anthracnose susceptible variety at Rubona. Ikinyange yielded highest among all varieties during 1986 A when there was little anthracnose pressure. During 1986 B, its yield relative to other varieties was severely reduced due to heavy anthracnose pressure.

Table 3. Sixteen most resistant lines to angular leaf spot over two locations and two seasons in the Great Lakes Region.

	ALS (1-9)	Yield (g 1.5^{-2}m)	Growth Type	Seed Color	Seed Size
A 221	1.6	140.0	II	Black	Small
A 240	1.8	170.0	II	Cream	Small
G 11526	1.8	137.9	II	Cream	Small
A 300	1.6	117.0	II	Cream	Small
A 339	1.8	133.4	II	Cream	Medium
A 216	1.8	123.0	III	Black	Small
G 5473	1.8	122.2	II	White	Small
A 212	1.8	118.0	II	Black	Small
A 345	1.6	87.4	II	Cream	Small
BAT 1647	1.8	85.5	II	Black	Small
G 5173	2.0	211.0	II	Black	Small
A 140	2.2	155.5	III	Cream	Small
BAT 963	2.2	102.6	III	Coffee	Medium
G 3666	2.0	165.4	II	Black	Small
G 2676	2.0	89.2	II	Black	Medium
BAT 1435	2.2	97.2	II	Yellow	Small
BAT 76 (Res)	2.0	70.8	II	Black	Small
BAT 1510 (Res)	2.2	124.0	III	Purple	Small
Munyu (Susc)	6.2	67.3	I	Coffee	Medium
Rubona 5 (Susc)	5.5	186.5	I	Red mottle	Large
LSD (P=0.05)	1.6	85.0			

1 = Symptomless, 9 = 25% of surface area covered.

Table 4. Best adapted new resistant parents to anthracnose for the Great Lakes Region (mean evaluation at Rubona, 1986).

Variety	Anthracnose (1-9)*	Yield (g 1-5m^{-2})	BCMV Black Root (1-9)**	Growth Habit	Seed Color	Seed Size
G 2618	1.0	141.5	1.0	3	cream	medium
P.I. 165.426	1.0	136.5	1.0	1	coffee	small
BAT 1275	1.0	134.5	1.0	1	purple mottle	medium
G 127227 (AB 136)	1.0	106.0	1.0	4	red	small
Cornell 49242	1.0	99.0	1.0	2	black	small
G 2333	1.0	97.5	1.0	4	red	small
G 3991	1.0	86.5	1.0	4	cream	small
G 7199	1.0	76.0	8.5	3	black	small
A 411 (res)	1.0	132.5	1.0	3	cream	medium
A 336 (res)	1.0	119.0	7.5	3	cream	small
Rubona 5 (Susc)	6.8	171.5	1.0	1	red mottle	large

* Anthracnose 1 = Symptomless 9 = 25% of surface area covered

** BCMV/Black Root: 1 = Symptomless; 2 -5 = Mosaic; 6 = Local lesions; 7 = Systemic necrosis stem; 8 = Few plants dead; 9 = Over 20% plants dead

Table 5. Number of advanced varieties evaluated for culinary quality in 1986 A and B.

Season	Trial name	National Program	Seed Source	Number of varieties
1986 A	Multi-locational trial	ISAR	Rubona	45
1986 A	Regional Trial	ISAR	Rubona, Rwerere	19
1986 B		PNL	Rubona	
		ISABU	Rubona, Karama	
1986 A	On-farm varietal trials	ISABU	Farmers	21
1986 B		ISAR		
1986 B	Comparative trial	ISAR	Rubona	41
			Karama	49
			Rwerere	36
			TOTAL =	211

Table 6. Great Lakes regional advanced bush bean trial 1986 A.

RUBONA, RWANDA Variety (1650 masl)	kg/ha	MULUNGU, ZAIRE Variety (1730 masl)	kg/Ha	RWERERE, RWANDA Variety (2100 MASL)	kg/Ha
A 197	2415	Nakaja	1209	Ikinimba	1782
Urubonobono	2314	Nain de Kyondo	1209	Ubusosera 6	1581
Kilyumukwe	2300	Urubonobono	925	Local mixture	1550
Ubusosera 6	2190	Ubusosera 6	824	Kirundo	1513
Nain de Kyondo	2150	Ikinimba	807	D 6	1288
Rubona 5	1915	Kirundo	768	Caraota	1207
Local mixture	1775	A 197	738	Nsizebashonje	1113
Nakaja	1750	Rubona 5	728	Nain de Kyondo	1094
D 6	1740	Muhinga	689	Nakaja	1088
Kirundo	1740	Nsizebashonje 4	608	Kilyumukwe	1069
Caraota	1600	Kilymukwe	518	Muhinga	1038
Muhinga	1590	Local mixture	509	Urubonobono	957
Nsizebashonje 4	1575	Caraota	415	A 197	608
Ikinimba	1415	D 6	425		
LSD.05	536	LSD.05	274	LSD.05	366
Average	1690	Average	741	Average	1246
CV = 19.8%		CV = 25.9 %		CV = 20.5%	

Table 7. Great Lakes regional advanced varietal trial 1986 B. Mean yields in kg/ha.

Variety	Source	Grain Type	Habit	Days[2]	Moso 1260M[1]	Karama 1300M	Murongwe 1470M	Rubona 1650M	Mulungu 1730M	Rwerere 2100M	Mean
Nakaja	Zaire	2p	IIIa	81	980	1325	540	1095	1788	525	1042
Nain de Kyondo	Zaire	1p	IIIb	86	725	1870	395	740	1425	750	984
Local mixture	Local	var	var	79	1080	1145	620	1190	951	725	952
HM 5-1	Burundi	3G	IIIa	75	770	680	825	1050	1138	1240	951
Ubusosera 6	Rwanda	4p	IIIa	83	880	1125	665	745	1250	810	913
Kirundo+	Burundi	3G	IIIa	76	840	950	905	860	988	900	907
Caraota	Zaire	6p	IIIa	77	915	1115	550	870	950	620	837
Urubonobono+	Burundi	1/9m	IIIb	78	900	945	495	750	1250	550	815
Kilyumukwe	Rwanda	7G	IIb	75	450	780	775	970	963	790	788
Ikinimba+	Rwanda	9M	IIIa	76	1420	600	480	560	713	915	781
Nsizebashonge 4	Rwanda	2/4p	IIIa	74	1125	845	460	635	613	765	741
D 6	Zaire	1/6G	I	75	495	915	795	880	638	695	736
Ikinyange (A 197)	Rwanda	2G	I	77	560	990	890	675	700	515	722
Bat 1375	Burundi	6p	IIa	80	585	940	395	510	1350	450	705
PVA 779	Burundi	1/6G	I	78	770	625	675	685	763	705	704
HM 21-7	Burundi	1/6M	I	74	780	830	665	725	650	555	701
Muhinga	Zaire	1/9rM	IIb	72	615	670	720	765	813	595	696
Rubona 5+	Rwanda	1/6M	I	77	720	620	535	730	963	465	672
A 410	Burundi	4M	IIa	79	1065	315	545	485	650	645	618
L. control var.	local	var	var	var	545	-	745	-	-	-	-
Mean					811	864	634	746	928	661	763
LSD.05					404	358	189	250	355	385	

+ highest yielding varieties of 1985 regional trial
1 Elevation: meters above sea level
2 Days to maturity at Rubona, Rwanda

Few varieties outperformed the average of locally selected farmers' mixtures across sites, even though at most sites specific varieties yielded significantly more than these mixtures. This indicates the importance of targeting many varieties for specific ecological zones. Varietal promise in these specific zones should be confirmed by on-farm varietal trials.

Regional trial materials were evaluated for cooking time and water absorption capacity in both 1986 A and 1986 B. No variety evaluated in either season took significantly longer to cook than the local mixture. However, it should be noted that, for unknown reasons, the local mixture took an unusually long time to cook. Some varieties, such as Nakaja in 1986 A and Hm 21-7 in 1986 B, cooked significantly faster than the local mixture (Table 8). Even though Urubonobono and Ikinimba did not take significantly longer to cook than the local mixture in the regional trial evaluation, both of these varieties absorbed significantly less water than the local mixture. This could indicate a tendency towards hard seed. These two varieties have been observed in other laboratory analyses and farmer evaluations to have long cooking times.

Table 8. Varieties in the regional trial which cooked significantly faster than the local mixture in 1986 A and 1986 B.

1986 A*		1986 B**	
Varietal Name	Cooking time (minutes)	Varietal Name	Cooking time (minutes)
Local mixture	60.83 abc	Local mixture	44.00 abcd
Kilyumukwe	49.17 de	Hm 21-7	26.33 e
Karaota	48.50 de	Nsizebashonje	26.33 e
Nakaja	48.17 de		
D 6	47.50 de		
Muhinga	44.50 e		
A 197	43.67 e		

LSD .05 = 11.23 LSD .05 = 13.88

* = Samples from Rubona and Rwerere. Environmental interaction not significant.

** = Samples from Karama. No varieties were significantly different from the local mixture in Rubona 1986 B.

Breeding varietal mixtures at CIAT for Africa

Varietal mixtures are widely used in the Great Lakes Region and in parts of Southern Africa. A collaborative project between the University of Munchen and CIAT, funded by GTZ, investigated the significance of mixtures in terms of yield gains due to physiological factors and disease control at CIAT. The objective was to obtain information to develop a strategy for improving variety mixtures. These provide the possibility of obtaining multiple disease resistant populations by physically mixing components resistant to different pathogens, or different races of the same pathogen. They also offer the possibility of improving local land races (mixtures) by adding one or more new disease resistant components to the farmers' mixture.

Four trials were conducted at CIAT with 9 genotypes, which were mixed in combinations of three, six and nine: three combinations of 3 genotypes, three combinations of 6 genotypes, and one mixture of all 9 genotypes. Trials were inoculated with rust 15 days after emergence. Plots were 6 m long and 6 rows (60 cm between rows) wide. Cowpea was planted between plots to reduce spore exchange.

On average, the largest benefit from mixtures was obtained by using equal proportions of growth habit II genotypes BAT 1297 (rust susceptible), XAN 43 (rust resistant) and PAI 49 (rust intermediate). This gave a 10.2% yield increase in 4 trials over the expected yield based on the pure cultures of the individual genotypes. The average yield gain for all mixtures was 5.1%, but no benefit was obtained where there was no variation for rust resistance. Mixture effects were found to be additive: the effects of 6 or 9 components could be predicted on the basis of the 3 component mixtures.

The genotypes which gained most from being planted in mixtures were BAT 1297 and PVMX 1531, and this was largely due to less rust in mixtures with resistant genotypes. In pure culture, the yield reduction due to rust was found to be 54% in BAT 1297, 31% in PVMX 1531, and 21% in XAN 33. The mean gain in yield of BAT 1297 over all mixtures was 100% in the rust inoculated trial, whereas its yield gain was 41% in the protected trial (Table 9). In other words, this genotype was gaining yield in mixtures because of protection from rust, as well as other factors. In this case, the susceptible cultivar would tend to increase in proportion from one generation to another, until the level of disease becomes such that the selection pressure favors again the resistant cultivar(s). This may be what would occur in a farmer's susceptible cultivar if a new disease resistant cultivar was introduced into the mixture, and suggests that large, and possibly sustainable, yield gains could be attained by adopting this strategy for variety improvement in parts of Africa.

The other factors found to be particularly important in determining the competitive ability of genotypes were their leaf area index at flowering, and tendency to lodge. Lines with low leaf area index (ICA 15438 and PAI 49) suffered more competition due to shading from neighboring genotypes. In addition, genotypes which tended to lodge (especially BAT 1297 and PVMX 1531) benefitted from being planted with erect genotypes, which provided support. Mixtures containing genotypes with different seed weights tended to lose their original composition very quickly, the large seeded types being eliminated. It is advisable, therefore, to work with genotypes with similar seed weight.

Table 9. Values of the mixture coefficient for individual genotypes planted together in equal proportions by seed number, where the mixture coefficient is defined as: single plant yield in mixture/single plant yield in pure culture.

a. Protected with fungicide

Genotype Mixture	1	2	3	12	13	23	123	Mean
ICA 15438	0.89	-	-	0.68	0.72	-	0.71	0.75
ICA L-23	1.13	-	-	1.14	0.99	-	0.97	1.06
BAT 1769	0.99	-	-	0.87	0.84	-	0.87	0.89
BAT 1297	-	1.37	-	1.44	-	1.52	1.37	1.42
XAN 43	-	1.07	-	1.21	-	0.99	1.23	1.13
PAI 49	-	1.71	-	0.75	-	0.61	0.66	0.68
PVMX 1531	-	-	1.32	-	1.45	1.40	1.17	1.33
XAN 33	-	-	1.05	-	1.03	0.94	1.16	1.05
G 12491	-	-	0.68	-	0.69	0.69	0.85	0.73

b. Inoculated with rust

Genotype Mixture	1	2	3	12	13	23	123	Mean
ICA 15438	0.81	-	-	0.72	0.69	-	0.73	0.78
ICA L-23	1.01	-	-	1.04	1.00	-	0.96	1.00
BAT 1769	1.00	-	-	1.08	1.18	-	0.89	1.04
BAT 1297	-	1.83	-	2.22	-	1.91	2.10	2.01
XAN 43	-	1.09	-	1.01	-	1.12	1.09	1.07
PAI 49	-	0.75	-	0.73	-	0.74	0.94	0.79
PVMX 1531	-	-	1.36	-	1.31	1.50	1.20	1.34
XAN 33	-	-	0.93	-	1.10	1.11	1.28	1.10
G 12491	-	-	0.86	-	0.87	0.81	0.81	0.84

On-farm research

The overall objectives for on-farm research in 1986 were to :

1. Conduct exploratory trials and varietal trials to orient research and evaluate promise of new varieties and technologies;
2. Test and assess methodologies for on-farm variety testing and diagnostic exploratory trials;
3. Institutionalize links between extension services and research institutes in agronomic and sociological evaluation of on-farm varietal trials.

The sharing of resources for on-farm research between national programs and agricultural projects and extension services was tested using Rwanda as a case study, and initial contacts with extension services were made in Burundi and Zaire. In Rwanda, more than 200 on-farm research trials (OFT) were installed during the year. Approximately sixty OFTs were installed in southern and northern Kivu by the national program of Zaire. In Burundi, 30 OFTs were established by the national program in six regions during the second season.

Interdisciplinary cooperation is an important aspect of on-farm research. The diagnostic exploratory trials were installed in Rwanda by phytopathologists and agronomists to ensure interdisciplinary diagnosis. Farmer evaluation of varieties was directed by a nutritionist and cropping systems specialist, and pathologists assisted in making disease observations.

On-farm variety trials

The primary objective of on-farm variety trials is to test the performance of promising varieties under farmers' conditions. Varietal characteristics are evaluated by both the researcher and the farmer. In Rwanda, on-farm variety trials proved to be both an effective diagnostic tool and a good instrument to initiate collaboration with extension services.

Rwanda. All varietal trials were installed under the farmers' management practices. Table 10 contains a summary of variety trials results for 1986. Bush beans currently being tested on-farm offer an impact on bean production only in the low altitude regions in the east of the country including Mugusa, Muhazi and Sake regions. The most promising varieties were Kilyumukwe, Rubona 5 and Ikinimba.

Farmers were asked to evaluate the varieties in four out of the ten communes where trials were installed. The results of 37 farmers' evaluations for culinary and agronomic characteristics are summarized in Table 11. Farmers evaluated all varieties for 19 agronomic and culinary characteristics using a hedonic scale of 1 to 5. A global score was also calculated for each variety. The calculation of global scores treats all characteristics as though they are of equal importance. Since this is most likely not the case, a weighting system is currently being developed for future data analysis.

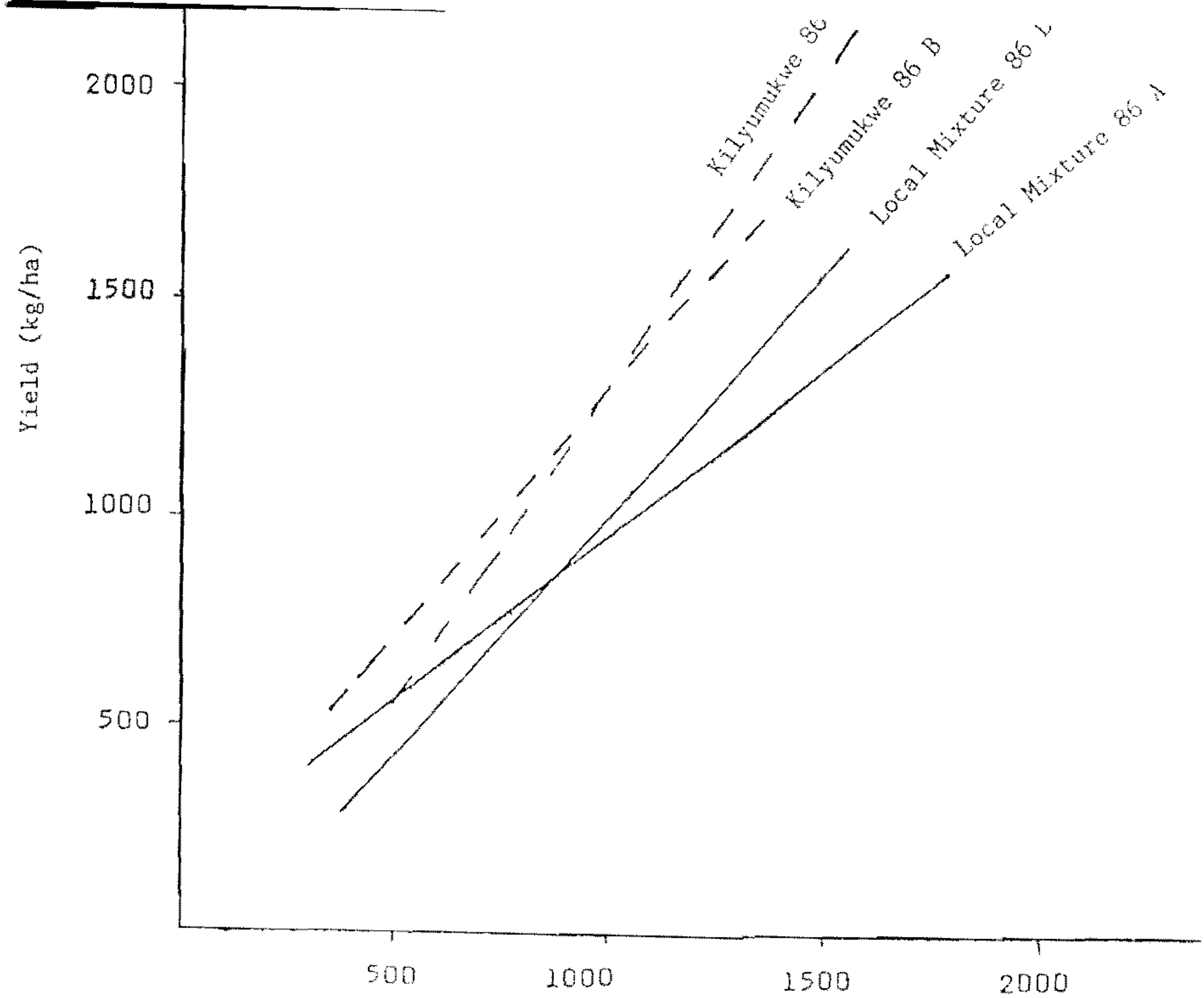
The farmer evaluation results correspond in general with yield data in these four communes. The three most preferred varieties by farmers were high yielding varieties: Kilyumukwe; a climbing bean mixture; and Rubona 5. Exceptions to this trend are Ikinimba, a black seeded variety, and Ikinyange, ISAR's 1986 released variety. The characteristics responsible for their lower farmer evaluations are listed in Table 11.

Table 12 shows that every one of the 45 farmers who had on-farm trials in the Rwandan areas of Nyabisindu and Ruhasya, were still growing Kilyumukwe two to six seasons later. Thirty-two of these 45 had first tried the variety at least five seasons ago. Moreover, the extent and quantity of diffusion of Kilyumukwe was double that of the next most retained variety, Rubona 5. Table 12 also shows a higher than expected rate of continued sowing of the variety Ikinimba, which received a relatively low overall score in farmers' trial evaluations. This is possibly accounted for by its relatively high productivity on poor soils. Ikinimba is planted to a much higher degree on infertile fields than are other varieties.

The performance of the local variety Kilyumukwe in the region of Muhazi (Eastern Plateau) merits special attention due to its outstanding yield performance over two seasons. Kilyumukwe was collected from northern Rwanda and has a large, purple grain type. In 1986 A it outyielded the local mixture by 34% and 46%, respectively. A yield stability analysis comparing average yield of all varieties in the trials with Kilyumukwe and the local mixture suggests that Kilyumukwe outperforms the control even under poor conditions (Figure 1). In 1986 A, however, an environment by variety interaction was evident, indicating that Kilyumukwe had more yield advantage under agronomically favorable conditions than under poor conditions.

Farmers in Muhazi preferred to continue planting Kilyumukwe significantly more than all other varieties, including the local mixture (Table 13). Kilyumukwe was also significantly preferred over the local mixture for its plant type, pod number, tolerance to poor soils, grain size and grain color. Among the 14 farmers who had on-farm variety trials in the commune of Muhazi during seasons 1986 A and 1986 B, 79% (11 farmers) have continued planting Kilyumukwe during the September 1986 season. Two out of the 14 farmers had already given Kilyumukwe to neighbors or family in exchange for other seed or as a gift. Given the superior yield of Kilyumukwe in the commune of Muhazi, the importance of yield to farmers in this region; and the high farmer acceptability of Kilyumukwe, one can conclude that the diffusion of Kilyumukwe in the commune of Muhazi will effectively increase bean production.

The strategy of encouraging extension services to participate in on-farm variety trials and other on-farm research in cooperation with the national program has been successful in identifying impact areas and connecting extensionists with researchers. Because of the close link between research and extension in planning and executing OFTs, Kilyumukwe will be for sale in seed distribution centers in the target region in April 1987. Demonstration plots have been established, and baseline data is being collected for a future adoption study.



Graph	Variety	Intersection (a)	Season (b)	Correlation	
-	Local Mixture	158.02	0.79	0.70	86A
	Local Mixture	-164.34	1.15	0.93	86B
-	Kilyumukwe	-174.57	1.48	0.89	86A
	Kilyumukwe	111.12	1.17	0.98	86B

Yield = a + be

+ e = Mean of all varieties tested in the trial.
* e = environmental index (Kg/ha)

Figure 1. Yield stability analysis for Kilyumukwe and Local Mixture in Muhazi (Rwanda) 1986 A/B.

Table 10. Yield data from farmer managed on-farm trials in Rwanda, 86 A/B (kg/ha).

Agro-ecological Zone	CRETE		CENTRAL PLATEAU+			GRANITIC SPUR			L. KIVU	MAHAGA		PL. D'EST		BUGESERA	
Communities / Varieties	MWENDO		TARE	RUSHASHY	MUSASA	NYABISINDU		RUHASHYA	MABANZA	MUGUSA		MUHAZI		SAKE	
	86A	86B	86B	86B	86B	86A	86B	86A	86B	86A	86B	86A	86B	86A	86B
Type I, II, III a															
Rubona 5	1208	184	473	446	558	2038	1035	1670	951	1849*	884	673	669	1645	649*
Kilyumukwe	358	318	477	402	790	2460	945	1830*	1052	2000*	876	1080*	910*	1540	631*
A 197 (Ikinyange)	-	-	-	-	-	2137	706	1600	-	1445	907	688	-	1564	-
Ikinimba	700	473	556	791	799	1820	1167	1764	1347	1849*	929	1074*	731	1712*	631*
Nsizebashonje	-	-	331	488	590	-	-	-	-	1897*	727	822	451	1441	464
Inyumba	-	228	-	-	-	-	-	-	-	-	-	-	-	-	-
Kirundo	1344	211	534	551	786	-	-	-	1089	-	-	-	779	-	524
Umutikili	-	-	-	-	-	-	-	1419	-	-	-	-	-	-	-
Tostado	-	299	-	-	-	-	-	-	1274	-	-	-	-	-	-
Ulusosera	-	-	-	-	626	-	-	-	-	-	-	-	-	-	-
Melange ISAR	-	434	468	505	485	-	834	-	1313	1661	827	-	662	-	524
Local mixture	1208	356	-	-	-	2139	1003	1603	1593	1393	847	805	622	1355	428
Type IV															
G 2333	-	-	728	683	1664	-	-	-	-	-	-	-	-	-	-
Cajamarca	-	-	12-	-	1206	-	-	-	-	-	-	-	-	-	-
G 2371	501	-	501	894	821	-	-	-	-	-	-	-	-	-	-
Climbing bean mixture	1094	-	-	-	-	2587	1061	1411	-	1481	984	-	-	2047	-
No. of trials	14	7	9	8	10	9	8	36	10	13	13	12	7	14	7
Altitude (masl)	2100	2100	1800-2100	1700-2000	1500-1800	1700	1700	1700	1600	1500	1500	1400-1500	1400-1500	1300-1400	1300-1400

+ no local mixture measured

* At p = 0,05 significantly superior to local mixture

Table 11. Evaluation by 37 farmers of on-farm trial varieties for agronomic and culinary characteristics in the communes of Muhazi, Ruhasya, Nyabisindu and Mugusa, Rwanda, during 1986 B.

		Score*						Specific Varietal Characteristics			
Variety Name	Global**	Cooking Time	Broth	Taste	Grain Size	Grain Color	Grain Quality		Score		Score
Kilyumukwe	58	100	100	66	100	100	100	Plant type	100	Pod size	75
Climbing bean mixture	24	100	66	66	-	-	66	Number of pods	66	Days to maturity	-100
Rubona 5	13	-	-	-	66	66	-				
Ikinyange	-2	100	66	-	66	-	-	Water absorption	-66		
ISAR Mixture	-10										
Ikinimba	-23	-100	-100	-100	100	-	-66	Tolerance to rain	-66	Preference to eat	-100

* Calculated according to the following formula: $\frac{A\ (1) + B\ (-1)}{\text{Number of evaluations}} \times 100$ Where A = the number of times a variety was evaluated significantly better than the local mixture.
B = the number of times a variety was evaluated significantly worse than the local mixtuere.

Only Scores 66 or -66 are listed. Maximum Score = 100. Minimum Score = -100. Local mixture has a score of 0.

** Based on results of all 19 characteristics evaluated.

Table 12. Follow up of on-farm varietal adaptation trials[a] Central Plateau and Granitic Spur, Rwanda 1986.

Variety	Percent of farmers still growing the Variety	Varietal diffusion		Sown Pure (P) Mixed (M)	Conditions under which it was grown*		
		No. of recipients	Total quantity diffused		Fert.	Infert.	Banana
Kilyumukwe	100%	51	453 Kg	P = 52% M = 48%	68%	4%	28%
Rubona 5	70%	24	270 Kg	P = 52%	48%	17%	35%
Ikinimba	67%	24	156 Kg	P = 40% M = 60%	45%	45%	10%
Kirundo	65%	16%	50 Kg	P = 34% M = 66%	72%	0	28%
A 197	22%	0	-	-	-	-	-
Climbing mixture	27%	5	-	-	-	-	-

* Sample size = 45 farmers

a Two of six seasons after having the varietal trial
32 of the 45 farmers had the trial 5 or 6 seasons ago.

Table 13. Evaluation of the variety Kilyumukwe in comparison to other varieties and the local mixture by 14 farmers in Muhazi, Kibungo, Rwanda, 1986 A and 1986 B.

Varietal name	Plant type (1-5)[1]	Number of pods (1-5)[1]	Tolerance of poor soils (1-5)[1]	Grain Size (1-5)[1]	Grain Color (1-5)[1]	Preference to continue planting (1-5)[1]
Kilyumukwe	1.31 a	1.54 a	2.36 a	1.00 a	1.00 a	1.13 a
Ikinimba	2.38 b	2.08 ab	2.36 a	2.14 b	3.71 c	2.59 b
Local mixture	2.50 b	2.67 b	3.20 b	3.17 c	2.83 b	2.38 b
Nsizebashonje	3.54 c	3.69 c	3.70 b	3.14 c	2.71 b	3.43 c

1 = Hedonic Scale 1 = Best ever seen
2 = Better than local mixture
3 = Equal to local mixture
4 = Worse than local mixture
5 = Worst ever seen

Table 14. Yields of ISABU varieties tested on-farm in six regions of Burundi, 1968 B cropping season. Mean yields in kg/ha.

		Natural Region					
Varieties	Origin	Kisozi	Ijenda	Kirimiro	Mparambo	Buyenzi	Moso
H. 75	Local cross	603	864*	1105		2030	
HM 5 - 1	Local cross	710	682*	1150			
D. d. Kirundo	Burundi	663	575			2120*	688
Urubonobono	Burundi	358	338	388			
HM 5 - 5	Local cross			1290			
HM 21 - 7	Local cross			629		1890	
A 410	CIAT				1325*		853*
PVA 779	CIAT				895		572
BAT 1375	CIAT				1093*		375
Aroana	Brazil				1164*		
Karama 1/2	Uganda				896		
Calima	Colombia						483
PVA 1186	CIAT					2950*	
BAT 1386	CIAT					430	
Local Check[1)]		832	328	1398	829	1162	610

1) Farmers' mixture or variety

* Variety significantly better then local check, (P = 0.05).

Burundi Five on-farm variety trials were installed in each of six different regions of Burundi in 1986 B. Yield data from these trials appears in Table 14. Although data for only one season is available, varieties like A 410 in the Moso area (low altitude, east of Burundi) and PVA 1186 in Buyenzi (medium altitude, north of Burundi) look quite promising.

Farmer evaluations of on-farm variety trial materials were initiated in Burundi in 1986 B (Table 15). Since each region's trials contained a different set of varieties, regional comparison of farmer evaluations must be interpreted with caution.

Table 15. Places and number of farmers who evaluated on-farm variety trial materials in Burundi 1986 B.

Location	Number of farmers	Most preferred variety	Good characteristics
Kisozi	5	Doré de Kirundo	Yield, color, maturity
Ijenda	5	Doré de Kirundo	Yield, color, maturity
Mparambo	5	Bat 1375	Yield
Kirimiro	5	HM5-5	Yield, seed quality Fast cooking time
Moso	5	A 410	Yield, maturity, taste

In Ijenda the varieties most preferred by farmers for continued planting are, in order of preference: Doré de Kirundo, H 75, and HM 5-1. It is interesting to note that farmers most preferred to continue planting Doré de Kirundo even though only H 75 and HM 5-1 significantly outyielded the local check. While farmers acknowledged the high yield of H 75, they did not like its later maturity.

Urubonobono, the variety chosen by ISABU for diffusion in high altitudes, yielded (in general) less than the local check due to susceptibility to Ascochyta blight, anthracnose and ALS. It also had very low farmer acceptability due to its long cooking time and longer maturity.

Of the three highest yielding varieties in Mparambo:A 410, Bat 1375 and Aroana (all CIAT introductions), Bat 1375 was most preferred by farmers for both eating and continued planting. It is interesting to note that farmers rated A 410 third in preference for continued planting due to its long cooking time. The variety A 410 was not found to have a long cooking time in laboratory tests or in farmer evaluations from Moso. A 410 should however be re-evaluated by farmers before it proceeds further in the varietal selection program. In Moso, the variety A 410 not only significantly outyielded the local check, but also received high ratings by farmers for its culinary and agronomic characteristics.

Bean diagnostic surveys

Diagnostics surveys identifying farmers' production constraints, cultural practices, varietal preferences, and bean consumption practices were conducted in several regions of all three countries in the Great Lakes Region during 1986 (Table 16). Data from two seasons are available only in southern Kivu, in Zaire, and Kibungo, in Rwanda. Diagnostic survey data from Burundi does not yet have an adequate sample size. PNL-Zaire began placing emphasis on diagnostic, on-farm research in 1986.

Table 16. Number of bean diagnostic surveys completed in the Great Lakes Region during 1986.

	Season		
	1986 A	1986 B	1986 C
Zaire			
Southern Kivu	125	137	
Burundi			
Mugamba	12	0	
Moso	11	0	
Kirimiro	13	0	
Mumirwa	43	0[1]	
Rwanda			
Kibungo	117	119	
Gisenyi	15	0	120
Butare	0	0	117

1 = Interviewers left for training

Exploratory trials

On-farm exploratory trials quantify information about major agronomic production constraints and provide, together with informal and formal diagnostic surveys, a basis from which to establish on-station and on-farm research priorities. These trials give baseline data about bean yields and the potential of beans in various agroecological zones. They also identify potential production increases through the elimination of production constraints.

In 1985 and 1986 a total of 50 exploratory trials was installed in various agroecological regions in Rwanda in collaboration with several agricultural and development projects. In 1986, 33 exploratory trials focusing on diseases were established in six agroecological zones in Burundi.

Two different trial designs were used in Rwanda. A plus one trial design was used in 1985, but was changed to a minus one design in 1986 due to the underestimation of soil fertility effects. The plus one trial design underestimates soil fertility effects because of a soil fertility/disease interaction (see the CIAT Annual Report for 1985). In the minus one design, lime application was eliminated as a factor in order to maintain the size of the trials. Factors tested included fungal and bacterial diseases, insect pests and soil fertility. Research program personnel and extension services participated in site selection, installation and evaluation.

Differences of 150 to 300% between potential and actual farmer yields were obtained in 1986 (Table 17). Most of the differences can be accounted for by augmentation of soil fertility and control of diseases. In the minus one design trials, both soil fertility and diseases were the most limiting. The plus design used earlier detected only diseases as the most limiting factor due to the interaction described above. In 1986, soil fertility was the most severely limiting factor in five out of six locations (Table 17). Pests were important only in three regions: the Bugesera; Lake Kivu shore; and the Zaire-Nile crest.

Table 17. Yield advantage obtained through control of diseases and pests and optimization of fertility using both minus and plus one designs in on-farm exploratory trials in Rwanda.

				YIELD ADVANTAGE RELATIVE TO FARMER CONTROL						
NATURAL REGION	Altitude (meters)	Season	Trial Design	Control of Diseases (kg/ha)	Control of Pests (kg/ha)	Augmentation of Soil fertility (kg/ha)	Reduction of Acidity (kg/ha)	Farmer Control (kg/ha)	Combined treatment	% Over Farmer Control
Zaire-Nile Crest		85 b	Plus[1]	556	623	489	334	444	–	
	2100	86 a,b	Minus[2]	381*a	150	605* a,b	–	1008	1508* a b	150
Buberuka Highlands		85 b	Plus[1]	556*b	-200	-156	-67	1500	–	
		86 a,b	Minus[2]	401*a	18	588* a	–	825	1884* a,b	228
Central Plateau		85 a,b	Plus[1]	640*a,b,b	190*,b	250	98	981	–	–
and	1700	86 b	Plus[1]							
Granitic Spur		86 b	Minus[2]	719* b	95	906* b	–	987	2935* b	297
Central	1900	86 b	Minus[2]	46	9	242* b	–	375	675* b	180
Plateau	1800	86 b	Minus[1]	550	150	567* b	–	833	1867* b	224
Mayaga	1400	85 b	Plus[1]	493	166	240	193	267	–	
		86 a,b	Minus[2]	299* b	104	399* b	–	1051	2056* a,b	196
Lake Kivu Shore	1450	86 b	Minus[2]	967* b	434	667	–	1133	2900* b	256
Bugesera	1200	85 a	Plus[1]	-9	297	8	-84	628	–	
Mean		85	Plus[1]	447 (59%)	233 (31%)	166 (22%)	112 (15%)	764	–	
		86	Minus[2]	497 (52%)	158 (17%)	566 (60%)	–	–	949 1995	(210%)

* a = Significantly different (P = .05) from farmer control in season A
* b = Significantly different (P = .05) from farmer control in season B
1 = Y factor - farmer control = Yield advantage
2 = Combined treatment - Y factor = Yield advantage

A comparison between a plus one and minus one design was conducted on the Central Plateau. It supported the hypothesis that the effect of fertilization interacts strongly with disease pressure (Table 18). Plus one trial designs tend to underestimate the severity of fertility as a limiting factor. The type and magnitude of this interaction varies across different levels of fertility and disease pressure. In locations of low soil fertility and high disease pressure the interaction is greatest, and most positive. These results indicate that removal of fertility as a limiting factor alone will often not result in expected yield increases unless diseases are simultaneously controlled.

Table 18. Direct comparison between plus and minus one trial designs in 1986B on the Granitic Spur in Rwanda.

Trial Design	Yield advantage relative to farmer control						Farmer Control	Combined Treatments
	Diseases kg/ha	%	Pests kg/ha	%	Fertility kg/ha	%	kg/ha	kg/ha
Minus one	1399*	(140)	169	(17)	1591*	(159)	1000	3497
Plus one	677*	(107)	151	(24)	308	(49)	633	---

Diseases caused a mean yield loss of between 52 and 59% in Rwanda and between 29 and 35% in Burundi. The severity of individual diseases was evaluated in the exploratory trials in Rwanda (Table 19). A similar study was conducted in Burundi (ISABU Rap. Ann. 1986 p. 128-146). The most prevalent diseases in both countries were angular leaf spot (Phaeoisariopsis griseola), anthracnose (Colletotrichum lindemuthianum), and Ascochyta (Ascochyta phaseolorum or Phoma exiqua pv. diversispora). Floury leaf spot (Mycovellosiella phaseoli) was common at middle to lower altitudes. Consistent plant loss was also observed from root rots, particularly in high altitude regions of Rwanda. Significant variability in disease severity over growing seasons was not found for any diseases except Ascochyta blight. Diseases such as rust (Uromyces appendiculatus), bean common mosaic virus (BCMV), common bacterial blight (Xanthomonas campestris pv. phaseoli), and halo blight (Pseudomonas syringae pv. phaseolicola are of more localized, secondary importance.

Target areas in Burundi and Rwanda for the control of specific diseases are listed in Table 20. Disease control may be obtained through the use of resistant varieties, cultural control methods or seed treatments. Similar exploratory research has been initiated in Zaire. Damage due to pests was the least limiting factor tested in exploratory trials. An average yield increase of 31% was observed using the plus one design. This increase in most locations was attributed mainly to control of bean fly (Ophiomya spencerella) (Table 21).

Many other pests were observed (Table 21), but generally at low populations. Bean fly occurred at both low and high altitudes in Rwanda. It is considered to be the only insect which justifies high priority input, especially on poor soils. Its presence is significantly more severe ($p = 0.05$) in the second season than the first (Table 22). It appears that the population starts to build up after the long dry season, continues increasing through the first season, and reaches a peak during the end of the second season. During the long dry season marshes may serve as population reservoirs of bean fly. Control of this pest on beans in marshes during the dry season may reduce populations to negligible levels for the main growing season.

Aphids, mainly Aphis fabae, were significantly ($p=0.05$) more important in the first season, but their levels were generally low in Rwanda (Tables 21, 22). This may also explain the generally low BCMV levels in farmers' fields. Thus, contrary to general opinion, these studies indicate aphids do not warrant much research input. Although they are predominant on isolated plants in farmers' mixtures, whole fields are rarely heavily infested.

Table 19. Mean relative prevalence of diseases in different regions of Rwanda evaluated in exploratory trials 1985, 1986.

Natural Region	Mean Altitude	% SA*	Asco % SA	Anth. % SA	ALS % SA	Rust % SA	Ram. (1-9)+	BCMV % SA	CBB (1-9)+	Rots Halo % SA
1. Buberuka	2100 m	9.87 a	3.5 bc	8.0 bc	0.6 b	1.2 de	1.1 e	0.9 bc	4.2 b	0.2 a
2. Zaire-Nile Crest	2000 m	6.58 ab	6.5 ab	17.7 a	0.6 b	3.6 bc	2.5 ab	1.7 b	6.3 a	0.0 b
3. Zaire-Nile Crest	2100 m	7.95 ab	10.2 a	11.3 b	0.2 b	0.2 e	1.3 de	0.8 bc	4.5 b	0.0 b
4. Mayaga	1450 m	0.96 c	0.4 c	10.3 b	0.6 b	4.7 b	2.4 abc	3.9 a	1.3 c	0.0 b
5. Granitic Spur	1700 m	6.81 ab	4.6 b	9.4 bc	1.1 b	2.8 bcd	2.1 bcd	0.6 bc	2.0 c	0.0 b
6. Central Plateau	1900 m	10.53 a	2.9 bc	7.1 bc	0.5 b	14.3 a	1.5 cdc	0.7 bc	0.0 d	0.0 b
7. Central Plateau	1700 m	0.49 c	10.0 a	5.7 c	0.4 b	1.6 cde	2.1 bcd	0.2 c	1.0 cd	0.0 b
8. Bugesera	1200 m	3.19 bc	2.7 b	10.5 bc	5.3 a	3.5 bc	3.0 a	3.4 a	3.4 b[r]	0.0 b

Values in column with the same letter do not differ significantly (LSD, P = 0.05)

* SA = Surface area infected

\+ = 1 = symptomless, 5 = moderate, 7 = severe, 9 = 50% plants dead

r = Macrophomina phaseolina

Table 20. Identification of target areas for diseases control in Burundi and Rwanda based on exploratory research 1985, 1986.

Country	Ascochyta blight	Anthracnose	Angular leaf spot	Rust	Floury leaf spot	BCMV	Halo blight	Common bacterial blight	Root rots	Web blight	*Macrophomina*
BURUNDI											
Mugamba (2100m)	x	x	x				x				
Buyenzi (1800m)	x		x	x			x				
Kirimiro (1700m)	x	x	x			x	x				
Kumoso (1250m)			x		x			x			
Imbo (850m)			x					x		x	
RWANDA											
Buberuka (2100m)	x	x	x				x		x		
Zaire-Nile Crest (2100m)	x	x	x				x		x		
Central Plateau (1700m)	x	x	x		x		x				
Granitic Spur (1700)	x	x	x				x				
Mayaga (1450m)			x		x	x		x			x
Bugesera (1200m)			x	x	x			x			

Table 21. Relative prevalence of pests in different regions of Rwanda over four consecutive seasons, 1985 and 1986.

Natural Region	Altitude	BEAN FLY (1-9)*	APHIDS (1-9)	Other insects and problems**
1. Buberuka	1800 - 2100m	2.7 de	2.5 a	a, b, o, p
2. Zaire-Nile Crest	2000m	1.0 f	2.5 a	
3. Zaire-Nile Crest	1900 - 2100m	3.7 bcd	1.2 b	a, b, p, r
4. Mayaga	1350 - 1500m	4.6 ab	1.0 b	c, d, e, f, g, h, j, m
5. Granitic Spur	1500 - 1700m	3.1 cde	1.6 b	s, c, i, k, l, m
6. Central Plateau	1800 - 1900m	2.4 e	1.0 b	
7. Central Plateau	1500 - 1700m	3.8 bc	1.2 b	c, k, f
8. Bugesera	1200 - 1300m	5.6 a	1.0 b	c, b, h, d, n, e, q

* Scale : 1 = no infestations, 3 = light, 5 = moderate, 7 = severe, 9 = 50% plants dead

** a. Altheca sp
b. leaf hoppers
c. Medythia quaterna
d. Maruca testulalis
e. mealy bugs on roots
f. weevils
g. Alcidodes leucogrammus
h. grasshoppers
i. Ophiomya spencerella
j. Ophomyia phaseoli
k. Caterpillars (heliothis spp.)
l. Bean web worm
m. Zonocerus elegans
n. Trichopusia sp.
o. rats
p. hail
q. Hippopotami
r. Kurisuka (weeds)
s. Mylabris (spp)

Research on the use of cultural methods to control disease

Beans in many regions of Africa are grown predominantly as varietal mixtures in subsistence agricultural systems. Research strategies must be oriented to obtaining maximum impact under the constraints this system of agriculture imposes. Impact using higher yielding and resistant varieties probably will not be as rapid in mixtures as when farmers cultivate only one bean variety, as often (e.g. the Great Lakes Region) new varieties are generally incorporated at varying percentages into the farmers' existing mixtures of bean varieties. For example, this means that if a variety yielding 30% more than the farmer's mixture occupies as much as 20% of the mixture, then the theoretical total yield increase would be only 6%. In a similar way resistant varieties will be diluted in mixtures of largely susceptible plants. In these regions variety-independent control measures such as cultural control, may have more rapid impact.

A number of trials were devised to evaluate the potential for reducing the level of diseases in beans using cultural methods. Trials included improved seed selection; and removal of diseased leaves and seedlings (particularly those infected with important seedborne diseases such as anthracnose, angular leaf spot, Asochyta blight and BCMV).

Over three seasons, a mean reduction in total disease severity of 40% (38% anthracnose, 45% angular leaf spot) was obtained by removing diseased leaves and seedlings. However, the practice of removing foliage and plants resulted in a numerical yield increase of only 6%, which was not significant at 95% level (Table 23). The removal of diseased seedlings alone reduced the inoculum source, but not the rate of infection, whereas leaf removal reduced the rate of spread (Figure 2). The combination of treatments decreased both the inoculum and rate of infection.

In looking at the variation in effects of the treatments over two seasons (no data was taken in one of the three seasons), the combined use of plucking diseased leaves and removing diseased seedlings resulted consistently in the most or second to most reduction in infection for the three diseases monitored: Ascochyta blight; angular leaf spot; and anthracnose (Figure 3).

In another trial, seed selection was included as one of the factors, in addition to removing diseased leaves and seedlings. Improved seed selection by itself resulted in an insignificant decrease in diseases and increase in yield. When all three treatments were combined they resulted in a 68% reduction ($p = 0.05$) in anthracnose and 49% reduction ($p = 0.05$) in total diseases. The yield increase of 12%, was not significant (Table 24).

These results indicate that cultural methods in combination show promise as an effective way to control diseases in varietal mixtures. While their immediate impact on yields may be negligible, they are likely to increase yields significantly in subsequent seasons through the availability of cleaner seed. In an experiment comparing disease free seed with other seed produced at the same location, a 22%

increase in yield was recorded. It is believed that the best use of these methods would be to employ them in the auto seed production activities by farmers in which good agronomic practices are combined with phytosanitary methods and possibly negative selection against diseased and low yielding plants by farmers using their own mixtures in special multiplication plots. This strategy is now being investigated on farmers' fields with farmers participating in the research.

Table 22. Effect of season on the severity of beanfly and aphid infestations.

Season	Beanfly	Aphids
September - January (A)	2.6 b	2.2 a
February - June (B)	4.4 a	1.1 b

Table 23. Effect of removal of diseased leaves and seedlings in three seasons on disease incidence and yield.

	Disease Infection (% surface area at R9)				
Treatment	ALS	Ascochyta Blight	Anthracnose	Total diseases	Yield
Control	6.8 A	0.1 A	6.2 A	12.9 A	1174.6 A
Removal of diseased leaves	4.8 BC	0.2 A	5.5 AB	10.6 A	1189.6 A
Removal of diseased seedlings	6.0 AB	0.2 A	4.9 AB	11.0 A	1207.3 A
Combined treatment	3.7 C	0.2 A	3.9 B	7.7 B	1237.9 A

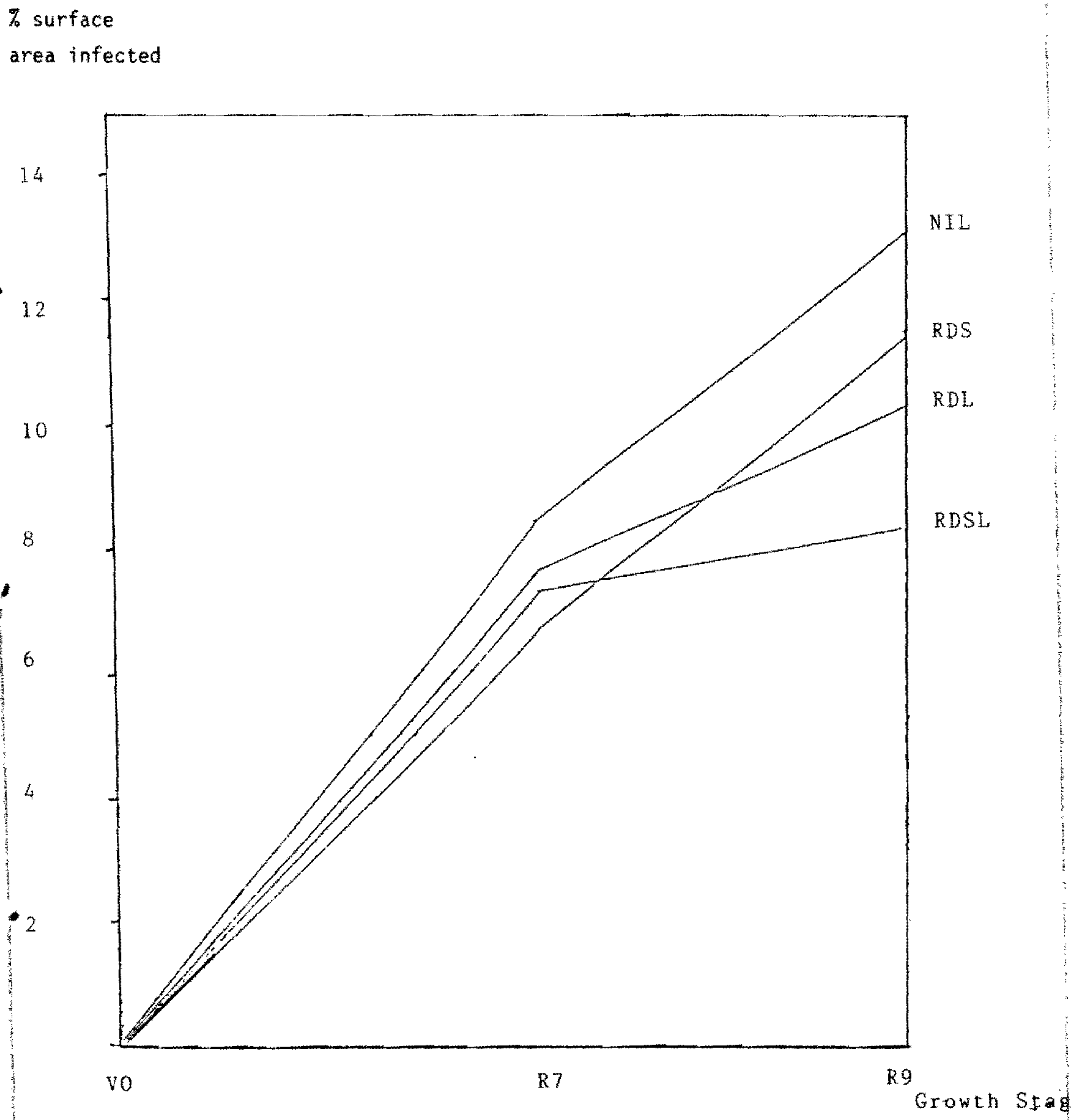
Values followed by letters which do not correspond differ significantly (p = 0.05) LSD

Table 24. Effects of seed selection, and removal of diseased leaves and seedlings, on seedborne disease development and yield.

Disease:	ALS		Anthracnose		Ascochyta		BCMV	Total Fungal Disease		Yield
Growth Stage:	R7	R9	R7	R9	R7	R9	R7	R7	R9	
NIL (Selection before sowing)	2.0a	5.8a	1.3a	7.8a	0.8a	0.0a	2.0a	4.1	13.6	535a
Selection after harvest and before sowing	2.0a	6.5a	0.4a	6.5a	1.0a	0.3a	1.3a	3.4	13.3	755a
Removal of diseased leaves	1.5a	4.0a	0.6a	6.6a	0.6 bc	0.1a	1.8a	2.7	10.7	420a
Removal of diseased plants	0.8a	6.3a	1.6a	7.8a	0.8abc	0.1a	1.5a	3.3	14.2	395a
Combined treatments	0.9a	4.0a	0.4a	2.5b	0.4c	0.4a	1.3a	1.7	6.9	600a

Numbers with the same letter do not differ significantly using LSD p = .05.

Combined treatments 0.9a 4.0a 2.5 b 0.4



igure 2. Disease development in experimental plots using removal of diseased leaves (RDL), removal of diseased seedlings (RDS), and a combination of both treatments (RDSL).

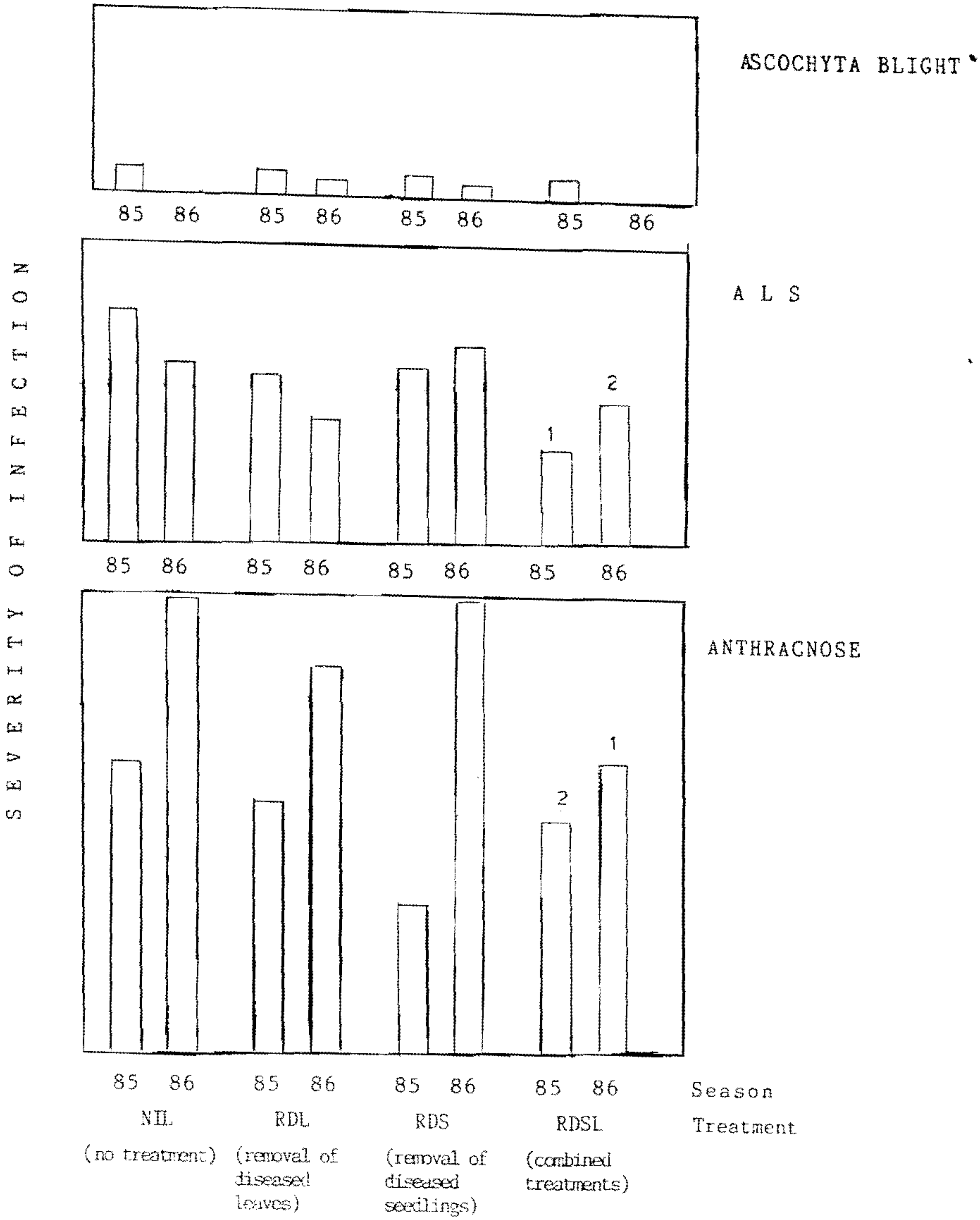


Figure 3. Seasonal variation in the development of fungal diseases using removal of diseased leaves and seedlings as treatments, alone and in combination.

The overall results of the acceptability evaluations by on-farm trial farmers in 1986 were good, but not as high as the most preferred bush bean variety Kilyumukwe. In 1986 A many of the trials had been installed under conditions unfavorable to climbers. A follow-up visit in Nyabisindu, Rwanda, indicated that in those cases where the trials had been located on very fertile soil and where the yields had consequently been high, farmers found the climbers to be excellent. Consequently, in the 1986 B season, more care was taken to planting the climbing bean mixture on good soil. Table 25 shows that the overall evaluation of the climbing bean mixture, during 1986 A was considerably better than the local mixture and second only to Kilyumukwe. It should be noted that the climbers were negatively rated for days to maturity. Attention needs to be placed on the implications of this factor for drought and other risks and on the placement of the climbers in farmers' systems.

Table 25. Comparison of farmers' evaluations of the climbing bean mixture with the most acceptable non-climber-(Kilyumukwe) - 1986 A. *

Place	No. of farmers	Climbing Bean Mixture	Kilyumukwe
Mugusa	12	2.8	4.6
Nyabisindu	14	3.0	4.8

* The rating scale is 1-5 where 1 = poor 3 = average and 5 = excellent

Particular attention was given to the question of climbing beans in the on-farm trial follow-up surveys. Only 27% of the 45 farmers with on-farm trials surveyed in Nyabisindu, Rhashya and Mugusa during 1986 had continued growing the climbers. Eighty-three percent of those who did stated they liked them very much and a further 13% stated that they liked them. Again, adoption seemed to be positively correlated to the initial good experience gained from having the trial on fertile fields.

Open-ended interviews with 24 farmers already growing climbing beans during 1986 A and 1986 B supported the above findings and were somewhat more encouraging than the trial follow-up surveys. All of these farmers had planted the climbers on fertile soil near the house. Eighty per cent of these farmers noted that they were approximately doubling their yields with the climbing beans. The other 20% had tried them for the first time that season and were not yet ready to draw conclusions. There was also a tendency for the neighbors of those farmers who had good results with climbers to start testing them. Still, most of these farmers were growing the climbers on small fields (100 m^2 and often much smaller). All of these farmers stated that they would like to expand the area in climbing beans, but were prevented from doing so by the lack of a readily available source of sufficient staking material. Other constraints that were frequently

Newly initiated research for technology development

Based on yield, disease and pest evaluations of exploratory trials, as well as informal and formal surveys, the program in 1986 initiated the following technology development and testing trials:

1. Seed treatments with fungicide, insecticide and calcareous powder for areas with root rot, bean fly and soil acidity problems;
2. A detailed study on the acceptability of climbing beans in the Central Plateau region with over 100 collaborating farmers;
3. On-station trials testing the integration of soil improvement components such as legume-trees and green manure crops in bean production systems;
4. Techniques to improve farmers' auto seed production using good agronomic and phytosanitary practices and basic selection methodology in special plots.

Constraints and potentials of climbing bean production in non-climbing bean areas

Average farm size in Rwanda and Burundi is less than one hectare, and population growth rate (about 3.5%) is very high. There is a great need for agricultural intensification. Climbing beans have a much higher yield potential than bush beans under fertile conditions. ISAR and the CIAT regional program decided that research on climbing beans should be given high priority. Diagnostic research during 1986 focused on identifying the constraints to and potentials of including climbing beans in systems where they are not currently being grown.

A multi-tiered approach was used to research this problem. Farmers' evaluations and follow-up interviews were obtained on the climbing bean mixture in the on-farm trials. A sample of 24 farmers who had spontaneously started growing climbing beans on a small scale were interviewed to find out what advantages and disadvantages they had found with the crop, their main production problems, and whether or not their neighbors were starting to adopt the practice. A survey of 120 farmers was carried out in the Gisenyi region of northern Rwanda where the great majority of farmers very successfully grow climbing beans. The purpose of these surveys was to discover if there were any aspects of their production techniques which could be transferred to other parts of the region, as well as to investigate what solutions they had found to the production problems that most limited climbing bean adoption in other areas.

The results of 117 general diagnostic surveys in the Granitic Spur and the Central Plateau in two communes of the Butare prefecture in Rwanda, showed that only about 5% of these farmers were actually growing climbing beans. If they grew climbing beans, they were cultivated only on tiny plots, usually accounting for less than 10% of their total bean production. They was no increase in the number of farmers cultivating climbing beans, and those already cultivating climbing beans were not increasing the area planted to climbers.

cited were the lack of climbing bean seed and the lack of fertile soil, compost or manure.

A supply of sufficient and readily available staking material is of primary importance. The Gisenyi survey was directed toward analyzing how farmers in this area had solved the problem. The rationale behind this research is that a solution or a practice carried out by these farmers may also be appropriate for other farmers in a different region within the country. Tables 26, 27, and 28 summarize some of the practices used by the Gisenyi farmers. More than 85% of these farmers had sufficient staking material for all their needs and did not find the extra work of staking to be bothersome. The main source of stakes was the anti-erosion hedges of Pennisetum planted in bands about 20 meters apart along the contour lines (Table 26). The farmers in Gisenyi also liked the multi-purpose nature of Pennisetum, as old stakes are an important fuel source for cooking, and the hedges provide considerable protection from erosion. Debris from the hedges help to maintain soil fertility and the leaves can be used for fodder.

Some farmers on the Central Plateau also grow Pennisetum, primarily for construction purposes. Their main problem with Pennisetum is that it is too competitive and reduces the yield of adjacent crops.

The techniques farmers used to manage their hedges to reduce competition was also identified in the Gisenyi survey (Table 27). The methods used include regular cutting, thinning and pruning of the hedge, as well as limiting the width of the Pennisetum band by cutting the roots on the field side of the hedge. Cutting takes place once a year, a few weeks before the major bean season. This provides sufficient stakes close to the field. The ensuing hoe cultivation incorporates the leaves and other debris into the soil, as well as cutting the roots extending into the field. At the time of first weeding the hedge is thinned if necessary and any plants growing out into the field are cut back.

In the Great Lakes Region an estimated 40-50% of total bean production occurs under agroforestry conditions, mainly under banana stands. Research into agroforestry was initiated in 1986, and has focused on tree density by bean growth habit interactions, as well as bean association with stake producing, nitrogen-fixing trees.

This research has indicated that a possible solution to the staking problem for the Central Plateau includes the use of novel cropping systems which integrate nitrogen-fixing trees like Sesbania sesban, Leucaena leucocephala and Calliandra calothyrus into bean fields. It is assumed that farmers will appreciate primarily the production of stakes for growing climbing beans and fodder, but these trees will also be used for the systems improvement effect of N-intake and P-recycling over time.

The acceptability of these new cropping systems is currently being tested on-farm and on-station, in collaboration with several projects and the agronomy department of the National University of Rwanda.

Basic trees and banana density by bean growth habit interactions are researched on-station, but will be increasingly researched on-farm. Preliminary data suggest that beans tolerate densities of up to 700 six-year old trees of Grevillea robusta without yield reduction. Climbing beans yielded higher than bust beans under dense banana association on-farm. This is of major importance for the extension of climbing beans in regions where they are not currently grown.

This association of climbing beans with thinned banana stands offers a solution to the drought stress and soil fertility problems in the Central Plateau. Banana stands close to the house are ubiquitous in the region, and tend to be fertile due to preferential household composting. Bananas provide shade and windbreak, thereby reducing the evapotranspiration considerably.

Future research into staking and agroforestry practices will involve farmers in the selection of trees and management practices. Farmers who would like to grow more climbing beans but do not find the necessary stakes will be the first group to address.

Table 26. Types and sources of staking material (120 farmers) in Gisenyi - 1986.

Type of stakes used (*)			Source of stakes		
Pennisetum	Bamboo	Wood	*Pennisetum* Anti-Erosion Hedges	Bamboo Groves	Woods lots * *Pennisetum* Groves
95%	22%	12%	68%	13%	19%

(*) Greater than 100% due to multiple types used.

1 Bamboo is only important as staking material at high altitudes above 2000 masl.

Table 27. *Pennisetum* hedge maintenance 1986 (120 farmers)

Cut back hedge once a year	Weed hedge	Thin hedge	Cut off non-vertical plants
93%	71%	76%	67%

Table 28. Staking practices and uses (120 farmers)

Durability of stakes (seasons)			Use of old stakes	Who obtains stakes?		Who stakes field?		Enough Stakes		Staking Bothersame	
2	3	4	Fire-wood	Man	Woman	Man	Woman	Yes	No	Yes	No
22%	63%	15%	100%	95%	25%	57%	89%	86%	14%	12%	88%

b. East Africa

The Eastern Africa regional bean program, the second of CIAT's regional projects in Africa, is now firmly established. A memorandum of agreement was signed with the Ministry of Agriculture of Somalia, and financial support from the USAID for regional activities to be carried out in Somalia and Uganda was finalized. Financial support obtained from the Canadian International Development Agency was used to post an agronomist to Ethiopia from mid-1986 to act also as regional coordinator, and a bean breeder was also attached to the Ethiopian national program for an eight month period.

The Eastern Africa regional bean program covers Ethiopia, Kenya, Somalia and Uganda; this large region is varied in several respects, including climate, cropping systems and utilization patterns for beans. Beans are the primary food legume in Kenya and Uganda, two of the five principal producers of beans in Africa.

Southwestern Uganda is the most important bean producing area of that country, and shares, with neighboring Rwanda, the urgent need for intensification of production on small, fragmented farms prone to soil erosion on steep slopes. Bean varietal mixtures and intercropping patterns of beans with maize, sorghum and banana suggest the likelihood of transferability of new bean varieties and cropping systems developed in the Great Lakes Region. Much of Kenya's bean production derives from maize/bean intercrops, grown by subsistence and small-scale commercial farmers. Half of Ethiopia's bean production, that destined for home consumption in the form of either boiled whole grain or a sauce made from legume flour, is intercropped in cereals. The other half of Ethiopia's bean production consists of small seeded white beans produced in low-rainfall areas for sale, much of it for the export canning trade. In Somalia, small quantities of beans are grown under dryland farming conditions or with supplementary irrigation.

CIAT's regional activities, guided by a steering committee including national bean program leaders, aim primarily to strengthen national capabilities to conduct research relevant to small farmers' needs. Special attention is being given to training, both at CIAT and in Africa. While post-graduate degree training has not yet commenced, two scientists from the Ugandan bean program, a breeder and a pathologist, have each spent approximately two months at CIAT for supervised training tailored to their specific needs. Two Ethiopian scientists received similar periods of training in bean pathology and in seed technology during 1986. Three other Ugandan scientists, capitalizing on their country's similarities with Rwanda, made short visits to learn more about breeding and agronomy research under the Great Lakes regional program. National program leaders of Ethiopia and Uganda also visited each other's programs and exchanged experiences and ideas. Links between Eastern and Southern African regions were also established by initial exchange visits between Ethiopia and Tanzania. A two-week training course was held in

Ethiopia for 17 research technicians working on beans and other pulse crops at seven government research stations and one non-government agricultural development project. The objective of the course was to improve standards of trial management and standardize data collection methods nationally.

CIAT regional staff made regular visits to Somalia, Uganda and also Tanzania. By participating in national research planning meetings and field visits, CIAT is assisting the development of more effective research programs within each country. On-farm surveys to diagnose farmers' problems in bean-producing areas, are being used to ensure relevant design of on-station research programs across several disciplines. Technology requires evaluation with farmers, and encouragement is being given to national efforts in producing seed of identified new varieties, and in the wider dissemination of research results to farmers. Assistance has been given to Ethiopia, Somalia and Uganda in assessing and documenting national research priorities in beans, through analyzing what resources are available for research, and in outlining future requirements for research staff development and for capital and operational investment.

Each country's variety development program is being strengthened by access to a wider range of germplasm. Assistance in identifying locally important problems is followed by the provision of specific nurseries (including those developed for bean common mosaic virus and for drought adaptation); introductions from CIAT's germplasm collection; advanced breeding materials from Latin America; and collaboration in evaluating germplasm.

In Uganda, many of the materials supplied earlier were lost during recent years of political unrest. This year lines salvaged from crossing blocks, VEFs and IBYANS were sown in unreplicated plots for further evaluation. A set of the AFBYAN was sown during the second season, the results of which are not yet available. Ugandan researchers made selections from Rwanda's breeding program (assisted by CIAT's Great Lakes regional project), during a field visit to their neighboring country: this material, formally presented to Uganda's President Museveni by Rwanda's President Habyarimana during a State Visit, is expected to provide materials well adapted to southwestern Uganda. Another approach to quickly revitalizing Uganda's ability to identify new varieties for farmers has been the return to Uganda in 1986 of progeny from crosses made at CIAT between K20, (a variety released by the Uganda program in 1968), and sources of resistance to diseases that have been its principal limitation. The Uganda program, based at Kawanda Research Station, this year selected and started using, a new trials site at Kachwekano, to serve the important southwestern zone.

Ethiopia's well-developed breeding program, which has already advanced selected materials supplied earlier by CIAT to national yield trials was augmented in 1986 by approximately 2000 new lines. All were grown in unreplicated plots with frequent local checks. Seed yields were estimated and disease and pest observations were made by national and regional scientists working collaboratively. The materials included entries from VEF 1985, IBYANs, and CIAT's germplasm Bank.

a) VEF 1985. Symptoms of BCMV and CBB ranged from absent to severe in 537 entries, many of which were completely free of the two diseases - the checks expressed moderate to severe symptoms of bacterial blight. Growth was generally excellent and yields ranged up to above 2 tons of dry seed per hectare. Among the check entries, Mexican 142 and Black Dessie produced the largest seed yields (1143 kg/ha) and Brown Speckled yielded the poorest (995 kg/ha). The heaviest seed yields (2179, 1951 and 1932 kg seed per hectare) were obtained from two representatives of the PAN (small white seeded) group. Other good groups of lines were those selected for Empoasca resistance (EMP) (up to 1741 kg/ha) and the small cream seeded, BAN group (1157-1641 kg/ha). Andean (205-1524 kg/ha), BLM (649-1470 kg/ha) and RIZ (587-1447 kg/ha) groups also contained lines that produced good yields, but other groups, including ICA lines (493-1343 kg/ha) and that of crosses made for Africa (273-1316 kg/ha) were not so promising.

b) IBYANs. Nearly 100 entries from various IBYANs were sown later than the optimum time, and growth and yield were less than in the VEF materials. In these conditions Brown Speckled (808 kg/ha) yielded best of the checks, with Mexican 142 (619 kg/ha) second and Red Wolaita (573 kg/ha) third. Among the IBYAN entries, the heaviest yield (2184 kg/ha) was obtained from one of the RAB lines. Other good yielders occurred in the PAN (1191 kg/ha) and RAO (1028 kg/ha) groups.

c) Germplasm. A set of about 1500 germplasm accessions representing the total range of variability in the CIAT germplasm collection and advanced lines from CIAT programs was also sown. Severe bean fly infestation resulting from the late sowing enabled evaluation of the collection for response to bean fly. Among the check entries, Brown Speckled showed significantly less damage (4.2 ± 0.19 on a scale of 1 to 9) due to bean fly than Mexican 142 (5.4 ± 0.20) and Red Wolaita (6.0 ± 0.27), but significantly more bean fly pupae per plant (7.5 ± 0.29) compared with 4.7 ± 0.35 for Mexican 142 and 6.4 ± 0.30 for Red Wolaita. Among the germplasm accessions, bean fly damage scores ranged between 2 and 9 and numbers of bean fly pupae per plant, from 2.4 to 25.4.

BIDAN. Materials introduced previously from CIAT performed well in national variety trials. In one set of trials of large seeded types, A 410 (3247 kg/ha) and A 262 (3104 kg/ha) produced far more seed than Brown Speckled (1912 kg/ha): in another set, Aguascalientes 13 (2134 kg/ha) was considerably better yielding than Brown Speckled (1335 kg/ha). In trials of colored, medium seeded types, A 442 (3419 kg/ha), A 62 (2928 kg/ha) and A 445 and BAC 87 (2852 kg/ha) produced much heavier seed yields than Black Dessie (2149 kg/ha).

Table 1. Yields of entries in VEF evaluation, Melkassa, Ethiopia, 1986.

Group	Number of Entries	Range kg/ha	Mean kg/ha	± SE
AFR	73	273-1316	893	3.01
AND	111	205-1524	976	2.25
RIZ	12	587-1447	1020	17.29
PVA	24	553-1210	856	8.31
ICA	127	493-1343	911	1.39
EMP	11	919-1741	1128	26.63
PAD	24	352-1339	802	11.39
PAN	27	333-2179	863	18.22
BLM	13	649-1470	1037	16.13
BAN	5	1157-1641	1359	41.22
Others	105	125-1266	874	2.28
Mexican 142	23	897-1698	1143	8.28
Black Dessie	23	585-1860	1143	13.41
Brown Speckled	24	716-1323	995	7.69

Collaboration with national programs in agronomy is focused in the short term on the development of appropriate on-farm testing of technology already available from research stations. The Institute for Agricultural Research of Ethiopia, through its Farming Systems and Socioeconomics Program, started two series of farmer-managed verification trials of the most advanced bean lines: four varieties of white pea (navy) beans were evaluated on farms in the Rift Valley, and four colored varieties were grown by farmers in the maize/bean subsistence systems of southern Ethiopia. Monitoring of these trials also helped the scientists to understand better the production systems within which beans are produced, and to design appropriate strategies for future interventions. For example, farmers in Ethiopia's Rift Valley are now known to adjust sowing rates for beans according to soil type; they often use a seeding rate higher than that recommended, because of their need to limit the yield loss that results from their shortage of labor on the farm at the time that beans require weeding. Attention will now be paid on research stations to establishing the potential value of selecting varieties that compete better with weeds. The importance of beans in the subsistence systems of southern and western Ethiopia, areas for which little research has been conducted on beans, warrants increased attention to intercropping, relay cropping and double cropping of beans with sorghum and with maize.

In support of the above activities, regional funds provided through CIAT by USAID and CIDA are being utilized for purchase of essential equipment for research stations and on-farm research. Decisions on such contributions are taken collectively by the steering committee, applying especially the criterion of importance of a proposed research activity for the region as a whole. Research topics provisionally agreed for regional collaboration among national programs in Eastern Africa include control of common bacterial blight (by Uganda), of bean rust (by Ethiopia), and drought tolerance (by Somalia). Collaborative research is also expected to link the three regional programs in Africa; for example, the topic of bean rust is to be shared with Tanzanian researchers.

c. Southern Africa

A Memorandum of Agreement (MOA) between CIAT and the Government of Tanzania was signed in April and the first of four CIAT scientists took up residence in July in Arusha in northern Tanzania, where the SADCC/CIAT Regional Program on Beans in Southern Africa has established its base. The breeder will move to Arusha in February 1987, and full funding from CIDA seems assured from March. SADCC's Southern African Center for Cooperation in Agricultural Research (SACCAR) has approved a second CIAT breeder for Malawi, and an Agreement between CIAT and the Government of Malawi has received Malawi approval, pending signature in March 1987.

The SADCC region covers Tanzania, Malawi, Zambia, Zimbabwe, Mozambique, Angola, Botswana, Lesotho and Swaziland, and is thus the largest of the three regions hosting a CIAT bean program in Africa. Bean production from the SADCC region amounts to about 564 thousand tons of dry seed, which is approximately a quarter of the total production of Africa. Tanzania produces about 350,000 tons, or 62 per cent of SADCC production. Within Tanzania, the major zones of bean production are the northern highlands of Arusha, Kilimanjaro and Tanga Regions, including the Pare and Usambara mountains; the highlands of central Tanzania, including the Uluguru mountains of Morogoro region; Kagera and Kigoma Regions of western Tanzania; and the southern highlands of Iringa, Mbeya and Rukwa Regions. Elsewhere, areas of food bean production include northern Zambia; the highlands of Malawi; Niassa, Tete and Manica districts of Mozambique; the central and eastern high veld of Zimbabwe; and parts of western Angola. The most northerly parts of the SADCC region receive rainfall in a bimodal pattern (the Short and Long Rains, October-December and March-June, respectively), whereas areas to the south of 6^{o}S (central Tanzania) receive rainfall in a single season. In northern Tanzania, the Long Rains are the chief season for beans but in western Tanzania the Short Rains are more important. As in Eastern Africa, maize is much the most important companion crop throughout Southern Africa; an exception is the Kagera Region of western Tanzania where banana-coffee-bean associations predominate. Bean production in Arusha Region is larger scale and more mechanized than elsewhere, in part a reflection of the seed bean industry centered here. In general, seed types are not as diverse as in the Great Lakes Region, and varietal mixtures do not predominate. A center of diversity in seed type within the SADCC region appears to include the area bounded by the southern highlands of Tanzania, northern Zambia, Malawi and the Niassa district of Mozambique. Canadian Wonder and red haricot (such as Masai Red) types predominate in northern Tanzania, and the large speckled "sugar bean" types are common further south. Climbing cultivars (type IV) are relatively uncommon.

The strength of national programs differs substantially across the nine countries. The Tanzania program is much the largest (with approximately 3 scientists at the Ph. D. level, 5 at the masters' level and 2 at the bachelors' degree level, working full-time on beans), although it is fragmented into separate teams in at least four different institutions. In most other countries in southern Africa, national scientists are part of grain legume research teams not devoted solely to beans, and several programs continue to rely on expatriate scientists. Notable achievements by national programs include the recent varietal releases of P 304 (as

Uyole 84) and T23 (as Lyamungu 85) in Tanzania, and of Carioca in Zambia. On average, Carioca has given 450 per cent increases in seed yield over the variety previously recommended in Zambia; it also performed well in on-farm trials, giving almost double the yield of farmers' varieties without added inputs. The line A 442 has given significantly heavier yields than Carioca in further on-station trials. Regression analysis of grain yields on disease scores reveals that angular leaf spot, anthracnose and scab were the most important diseases in causing yield loss. Several bean lines have combined resistance to these, and G 2338 has been shown to possess effective resistance against all the major diseases at two contrasting sites in Zambia.

CIAT's regional activities have included the conduct of the first steering committee meeting, the convening of a bean fly workshop in Arusha, and attendance of a board meeting of SACCAR in Lusaka. The regional co-ordinator and the breeder contributed to the Annual CRSP-supported workshop on bean research and they each attended the Tanzanian national commodity crop coordinating meetings, held in Morogoro in September and November, respectively. Steps have been made towards the more effective coordination of variety trials across sites, and across institutions concerned with bean research in Tanzania. Further progress was made in the establishment of the African Bean Yield and Adaptation Nursery (AFBYAN) and the Regional Bean Fly Resistance Nursery (RBFRN).

The steering committee meeting, which was attended by national bean coordinators from Botswana, Lesotho, Mozambique, Zambia and Tanzania as well as by representatives from SACCAR, CIDA and CIAT, helped to establish priorities for the purchase of equipment and for training. An agronomist from Tanzania received short-term training in on-farm research methods at CIAT headquarters, and a course for research technicians is planned to be held in Malawi in March 1987. Together, these regional activities have begun to stimulate links between individual scientists which in turn will lead to the formation of an effective network among national programs throughout the SADCC region.

8. Collaborative Bean Research, IVT (Instituut voor de Veredeling van Tuinbouwgewassen)-CIAT

CIAT has collaborated on a bean breeding project with the Institute for Horticultural Plant Breeding (IVT) in the Netherlands. This year's research has concentrated on incorporating resistance to viruses into CIAT bred lines.

Incorporation of virus resistance genes: IVT 7233 x IVT 7214

Eight F_2 populations from crosses made between IVT 7233 and NL-5 IVT 7214 and a CIAT progenitor were subjected to BCMV strains NL- 3 and NL-5 to select symptomless plants carrying the bc-3 gene. The 1985 IVT-CIAT report listed the F^2 populations selected for containing the bc-3 gene; the number of symptomless plants; and the quantity of F^3 seeds harvested with which F^1 testcross seeds could be obtained. Test crosses were made to select bc-3 carrying plants which also carried bc-u and $bc-2^2$ genes in a homozygous farm. Gene I was present in both parents. The quantity of testcross seeds was limited, and plants with double resistance could not be selected from F^2 populations in 1986 through further screening of the plants from tests with BCMV-N strains, 3, 4 + 5. Consequently, testcrossing continued in the F^3 lines. Five promising plants from each of the three F^3 lines per cross were selected for seed color. Selections made at CIAT for color from the same lines were also used. F^4 seed was harvested from the crossed F^3 plants, and F^1 seed from the GN31 plants onto which the testcrosses were made, was also collected. A total of 44 F^3 lines were used for testcrossing.

Table 1 shows the presence of the bc-u and $bc-2^2$ genes in the individual F^3 plants, based on screening of BCMV strains NL-3, NL-4 and NL-5 in the F^1 testcross seeds. Results were available from 30 of the 44 lines. Ideal resistance (both $bc-2^2$ and bc-u genes homozygously present) were found in only 3 of the 30 lines. Genotypes in which bc-u is heterozygous (u+/u) were detected in eight lines, and genotypes with bc-u absent (u+/u+) in 15 lines. Symptoms did not develop in this group, and no systemic spread of the virus occurred. If the bc-3 gene is ever overcome, then $u+/u-2^2/2^2$ I/I, and $u^+/u^+2^2/2^2$I/I would show only local necrosis.

F_4 progenies within each of the three resistance groups were used to compose line mixtures having the same resistance genotype, seed type and seed color (within the respective seed color groups). In some cases only one progeny was used as 'final material'. The 14 single or joined progenies are indicated as populations in Table 1. Two populations came from navy beans, although the $bc-2^2$ gene was not detected, probably because of absence in the IVT 831575 seed. Although it does not carry real double resistance, the combination I bc-3 remains of value.

Table 1. F3 plants showing double resistance in testcross results, and number of released populations from mixed lines having same seed type and genotype.

F^3 Line	Plants Test-crossed	Plants with $2^2/2^23/3I/I$ and u/u u^+/u u^+/u^+				Populations released
Small white navy						
IVT 831575 x PAN 29, 2 CIAT lines	10	-	-	-	-	1
" x PAN , 1 CIAT lines	4	-	-	-	-	1
" x Fleet-wood, 3 CIAT lines	15	-	-	-	-	-
Small red, brilliant				2	1	
IVT 831607 x RAB 71, 2 CIAT lines	8	-	-	-	-	-
IVT 831607 x RAB 71, 4 IVT lines	17	-	3	5	4	3
Small black, brilliant						
IVT 831607 x RAB 71, 1 CIAT line	5	-	-	-	-	-
" x RAB 71, 5 IVT lines	23		1	2	10	3
Medium black, opaque						
IVT 831629 x BAT 1554, 1 CIAT line	5	-	-	-	2	1
" x BAT 1554, 5 IVT lines	24	4	3	10	3	and 1
Medium red mottled, kidneys						
IVT 831657 x BAT 1412, 3 CIAT lines	15	-	2	3	2	
" x BAT 1412, 3 IVT lines	14	-	-	2	-	

1. Population with pinto colored seeds

Seed will be multiplied at CIAT, and best adapted populations will be included in international trials. Seed types important to Latin America and Africa which have valuable resistance to BCMV, will then be disseminated to recipient collaborative countries.

Materials from the medium white, medium yellow, and red mottled color groups will be sent to CIAT in the Spring of 1987. Program A of the collaborative IVT-CIAT project will be terminated with the shipment of these materials, all derived from crosses between CIAT breeding lines and the IVT 7233 x IVT 7214 source of double resistance.

Program with IVT 7620

Testing for plants resistant to the BCMV-Tn strain continued. Selections came from the first, second and third crossing generations derived from CIAT lines x IVT 7620. IVT 7620 comes from an interspecific cross with *P. coccineus*, and has resistance to BCMV and BYMV (including the Tn strain).

Some F^2 progenies out of five crossing populations from the third generation which showed no systemic virus spread in last year's tests with BYMV-Tn, showed susceptibility this year. IVT 7620 resistance to BYMV was apparently lost in the second crossing generation, due to primary screening for resistance to BCMV in the first two generations.

Excellent resistance to BYMV, however, was selected in the first crossing generation between CIAT breeding lines and IVT 7620, as was reported in 1985. Further screening of plant selections continued this year. Plant progenies were selected in which all plants were symptomless, and having no plant with detectable virus in infection tests on plants of the very sensitive variety Widusa. Plants showed no detectable virus infection, and this resistance was confirmed in further testing. Progenies were joined with sub-lines 34-2 and 34-6 (from line 5) and with 35-4 (from line 6). These populations have complete resistance to BYMV, and proved superior when compared to all other materials from various countries. They also maintained complete resistance to all strains of BCMV, thanks to resistance supplied by *P. coccineus* via the IVT 7620 parent line. This F^6 material is considerably more valuable for breeding purposes, than is the parent IVT 7620. The disadvantages of the interspecific cross are still detectable in the IVT 7620, as evidenced in deviating, rectangular seeds, puckered and narrow light green leaflets, and short pods. The new selections are strong plants with dark leaves and have a normal seed and plant type. The sub-line populations are ready for release and will be sent to CIAT as final materials. IVT 7620 was crossed with BYMV-susceptible CIAT accessions G 08066, Negro 321, and C 63s630B, but complete resistance was achieved only from crosses with G 08066. The seeds of all three populations are grayish-white, while there are slight differences in leaf and seed forms. G 08066 comes from crosses made between 'Pop' from Uganda, and the Costa Rican variety, Nep 2. IVT 7620 comes from crosses made between a Dutch bush runner bean, a Dutch bush slicing bean (*P. vulgaris*), and a Yugoslavian dry bean.

III. EVALUATION AND IMPROVEMENT OF AGRONOMIC PRACTICES

A. On-Farm Research

On-farm research activities in 1986 continued in the areas of training, network establishment, methodology adaptation, technology development on-farm and technology adaptation to specific areas. Feedback to research on-station, both in CIAT and in national programs is an aim implicit in these activities. Training and the support of those already trained, increased in importance in 1986, and now represents 60% of the activities in on-farm research. Networks of on-farm researchers are starting to form within countries like Peru and Colombia, which have received special attention in training activities.

Testing of new ideas in methodology for on-farm research continued in Colombia. Trials aimed at integrating on-station and on-farm research activities were emphasized. These usually tested what could be gained by technology development on-farm (see, for example, the Microbiology section of this report). Our collaborators in other countries adapted methodologies to their own situations and thus provided information and suggestions for participants in future on-farm research courses.

On-farm research training

In 1986 the final courses were held in the "Pilot project on training and networking in on-farm research in Latin America". These included an intensive CIAT-based course, with various follow-up activities, and the third and final phase of the INIPA-CIAT on-farm research course for beans in Peru.

The number of participants in the On-Farm Research-Bean Cropping System Course held March-April 1986 at CIAT, expanded to 23. Thirteen participants were included from ICA, Colombia, where there has been particular interest in OFR. Only four of the participants attended the multidisciplinary course beforehand; the others received a one-week refresher-course on biological aspects of diagnosis in beans. This also kept the period of study short (eight weeks total), which is desirable since many participants are responsible for extension districts or OFR projects and find it difficult to be absent for long periods. Follow-up activities, four to seven months after the end of the course, included a one-week workshop for Colombian participants, and visits by CIAT staff to other participants.

The final phase of the INIPA-CIAT course was held in CIP headquarters in Lima. Twenty-one of the 25 participants attending the second phase attended: two of those who left for other jobs were replaced, and the work originally planned in 24 of the 25 zones was completed. 82% of planned trials were successfully planted and executed (133 in total) and 214 new trials were planned on the basis of analysis and discussions in the course. Integration of research and extension personnel, mutual support, and a new dynamism and relevance in the work of many participants, are the most notable products of the course. Consultancy from CIAT will continue.

In total, 87 on-farm researchers have been trained in Bean Program courses between 1984 and 1986 (Table 1). Plans for a new phase of OFR training are now being prepared.

Table 1. Scientists participating in CIAT OFR training, by country, 1984-1986.

Country (Total no. of participants)	Type of Institution	No. of participants in course: CIAT 1984	CIAT 1985	CIAT 1986	Peru 1985-6	Central America 1985-6	Total
Peru (25)	Research	2		2	11		11[a]
	Extension	1		1	14		14[a]
Colombia (19)	Research		1	5			6
	Rural development	3	1	9			13
Costa Rica (16)	Research	1		1		2	4
	Extension	1	1			10	12
Guatemala (6)	Farm testing teams	2	1			2	5
	Extension		1				1
El Salvador (6)	Research		2	1		1	4
	Extension			1		1	2
Ecuador (4)	Research		1				1
	Farm testing teams	1	1	1			3
Mexico (3)	Research			2			2
	University teaching & research		1				1
Honduras (3)	Research		1			2	3
Nicaragua (3)	Research					2	2
	Extension		1				1
Dominican Republic (2)	Extension	1	1				2
		12	13	23	25	20	87*

[a] All the 6 Peruvian participants in CIAT courses also attended the in-country course. Double-counting has been avoided.

Technology adaptation to specific areas

Various examples of technology adaptation to specific areas have been discussed in the 1983, 1984 and 1985 Bean Program Annual Reports. Highlights in 1986 were:

a. On-farm research trials were conducted by members of the INIPA-CIAT on-farm research course on beans in 24 areas of Peru, in almost all of them for the first time. One early result is a much better understanding of the variability in the adaptation of the newly adopted variety Gloriabamba in different parts of Cajamarca department. The areas in which planting in rows and fertilizer application are promising have also been defined by results of the same trials.

b. In Ipiales, Colombia, a wide selection of technologies which can be adopted one by one is now available to the farmer. Foliar fungicide application, seed treatment with fungicide and closer within-row spacing for the variety Frijolica 0-3.2 are all in farmer-managed trials. The promising line TIB 30-42 is at the same stage. Farmers are multiplying seed of both, with ICA guidance.

c. Frijolica LS 3.3, released by ICA in 1985, is being tested in farmer-managed trials in San Vicente, Antioquia together with improved foliar fungicide applications and seed treatment with fungicide. Its seed is also being multiplied by farmers.

d. Farmers in part of Funes, Colombia, have adopted the bush-bean line Ancash 66, apparently because of its tolerance to poor soils. The line has not been released by ICA because it matures too late to be effective in the whole of the Funes target area.

The comparison of agronomic results between experimental station and farms

This special topic which is reported in detail in this section was studied during four seasons, from 1982 B to 1985 B. Results were compared between Obonuco experimental station (2710 m above sea level) and the Ipiales area of on-farm research (2500-2800 m above sea level), 80 km distant, which it serves. In the Bean Program Annual Report for 1984, differences were shown in the performance of a group of ten elite lines between Obonuco and Ipiales. There was no correlation between station and farm results, and the line released as a result of farm trials was in sixth place on the station. In this year's report, results will be presented from 11 of the 14 other trials designed for the Ipiales target zone of which copies were planted at Obonuco. The trials combined changes in cultural practices with changes in maize and bean varieties.

In 1982 B, the field provided for the trials at Obonuco was infertile and atypical of conditions there. Possibly as a result of this, the effects on beans of changes in variety, and on maize and beans of changes in spatial arrangement, were similar to those on-farm. There was, however, a large effect on beans of foliar disease control on farms, but none on-station (Table 3). On both station and farm, there was little effect on beans of increasing fertilizer dose. Increased fertilization greatly increased maize yield on-station, but reduced it on-farm.

On-farm, but not on-station, bean plants were lost in the high fertilizer treatment, apparently because their roots were burnt by fertilizer. This was checked in 1983 B. At Obonuco, the best bean yields were obtained with a rock phosphate/diammonium phosphate (RP/DAP) mixture applied beneath the seed at planting. Differences between treatments were small, and fertilizer application methods did not affect maize or bean stand (Table 4). However, in Ipiales the RP/DAP mixture gave the lowest maize and bean yields and reduced the stand of both. The plant loss was probably due to the urea included in the mixture. On-farm, the highest bean yields and stands were obtained when fertilizer was applied side-dressed at ridging up (i.e. at about 6 weeks in a 36 week growth cycle). This is the method most commonly used by farmers in Ipiales. The highest maize yields were obtained when fertilizer was applied at planting time in a second hole at the side of the seed, but bean yields were in this case reduced by maize competition. The trial suggested that to increase maize and bean yields in Obonuco by applying more than 100 kg/ha of the compound fertilizer 13-26-6 it would be necessary to apply fertilizer at planting time, but on-farm there was a response provided that fertilizer was applied by a method which did not burn the small plants. In Obonuco, frequent light rains avoided the formation of a fertilizer crust below the seed, but on-farm in Ipiales, drought after planting was common.

Optimum fertilizer doses for applications side-dressed at ridging-up were studied for three years in Ipiales on three farms per year. Each year a copy was planted in Obonuco. At Obonuco, there was no response to either N or P in beans and a response only up to 39N in maize (the optimum response in fact, was different each year, to 13N, 39N and 65N respectively). On-station the results of the additional treatments suggested that farmers are correct in applying 100 kg/ha of 13-26-6, but that no increase in maize or bean yield can be expected after this (Table 5). Thus on the basis of station results, the only modification in existing practices to be considered would be the application of extra nitrogen to benefit maize.

The results on-farm were different. There was a response up to 65N in maize, and these high levels helped beans to recover from the adverse competition experienced when maize responded to the lower dose of 39N. Beans responded to P, but insufficiently to cover the cost of application. Beans also responded to K without depressing maize yield. The benefits obtained from N, P and K all suggested that an application of at least 300 kg/ha of 13-26-6 would be desirable, and this was confirmed by the additional treatments.

Spatial arrangements of maize and beans were also studied intensively after 1982 B, with the aim of increasing bean yield, and maize yield if possible, by using higher densities of beans less vigorous than Mortiño. The lines TIB 30-42 and 32980-1-41 gave the highest net benefit with 4B 2M (4 bean seeds and 2 maize seeds) at 0.5m on both station and farms. However, Frijolica 0-3.2 was best with 3B 3M at 0.65 m in Obonuco but with 3B 2M at 0.5m on farms (Table 6). Farmers however tended to reject close within-row spacing, and preferred 0.8m or more. With this limitation imposed, the station results would lead to a recommendation of 4B 4M at 1.0m; whereas the farm results, suggest 3B 3M at 0.8m. Additionally, the station underestimated the benefits of the line TIB 30-42 compared to Mortiño. When both were compared at farmers' spatial arrangement (2B 4M at 1.0m), Mortiño was economically favored on-station but not on-farms.

In 1985 B, the trial included other maize and bean varietal combinations. Results again showed many contrasts. The early maize population, Pool 7, developed poorly on-station but well on-farms. Thus, on-station, TIB 30-42 dominated Pool 7 and 4B 4M at 1.0m was favored. On-farms they were more balanced in competition and 4B 3M at 0.8m was the best combination (Table 7). Similarly Pool 7 and Morocho Blanco were partners of similar merit for Frijolica 0-3.2 on farms, but Pool 7 was inadequate on-station. For Morocho Blanco with Frijolica 0-3.2, the best planting arrangement was 3B 4M at 1.0m on-station but 4B 3M at 0.8m on-farm. These results reflect the greater vigor of beans on-station compared to farms.

In other trials too, early maize populations like Pool 7 performed poorly at Obonuco, a cold, windy environment (2710m), but performed well in parts of the target area below approximately 2650m. In trials intended to intensify the cropping cycle by using maize and beans of early maturity and including barley afterwards, Cundinamarca 431 maize yielded the same as Morocho Blanco on-farm (2.7 t/ha) but much less on-station (0.9 t/ha compared to 2.1 t/ha). In this case, the preliminary warning provided by the station results proved correct, since from 1983 B to 1985 B Cundinamarca 431 performed poorly on-farm, although still better than at Obonuco.

Seed treatment trials were also planted on both station and farms in 1982 B and 1983 B. They gave different results because Fusarium late wilt was the main problem on-farm, but soil insects appeared to be important at Obonuco.

Occasionally, the difference between station and farms was the result of problems in applying the treatments on-farm. In a set of verification trials in 1984 B, the intention was to add benomyl to the foliar applications used by farmers, but not to use insecticide.

Three applications of mancozeb with metamidophos or parathion insecticide is the most common farmers' practice, but varies according to the conditions they observe in the field. Thus, the 103 kg/ha advantage in beans (Table 8) of changing fumigation practices measured at Obonuco is truly the effect of adding benomyl. On-farm, there was considerable incidence of rust. Half of the farmers used sulphur or oxycarboxin to control rust, so the 52 kg/ha increase measured is the difference between various strategies for control of rust and insects and a strategy which effectively controls anthracnose. The same farmers' strategy explains why the line 32980-1-41 which is moderately susceptible to rust and anthracnose, responded less to the new fumigation practice on-farm than Frijolica 0-3.2 which is more tolerant of anthracnose and rust. On-station, however, their positions were reversed.

Obonuco is an experimental station which is close to its target area, similar in climate and soils and managed under similar cropping systems. Despite this, optimal fertilizer dose, fertilizer application method, spatial arrangements and plant densities were different on-farm from those obtained on-station. The effects of seed treatment and fumigation were also different between farms and station. It can be concluded therefore that different results for these practices would be obtained in most cases of farm-station comparisons. The competitive balance between maize and beans was particularly sensitive to small differences in environment between Obonuco and Ipiales. Thus, the slightly lower temperatures in Ipiales in comparison to most of the target area, damaged the growth of early maize cultivars on station and upset the balance of competition with early-maturing beans.

In 1982 B, when an infertile field was used that was not typical of Obonuco, but was similar to farms, some results were closer to those obtained on-farm. This suggests that careful selection of a station field might permit prediction of results on-farm. However, even in this case (see Table 3) many different results were obtained, and the strategy is not reliable.

The results from the four years' study underline the need for fertilizer, density and plant protection practices to be developed and tested from an early stage on-farm. For these practices, station trials, however well conducted, are likely to be misleading.

Table 2. Number and type of trials planted on farms in different regions of Colombia. 1985 B and 1986 A.

Type of trial	Eastern Antioquia (San Vicente) 1985B	Southern Nariño (Ipiales) 1985B	Central Nariño (Funes) 1985B	Northern Nariño (El Tambo) 1985B	Eastern Antioquia (El Carmen) 1985B/1986A
Variety					
Segregating generations or advanced lines	5[a]	3	6[b]	6[b]	-
Bean varieties	3[a]	5[a]	-	3	-
Early maize varieties	-	2	-	-	-
Exploratory	-	-	-	-	6[c]
Determination of economic levels					
Maize x bean varieties x planting arragement	-	4[a]	-	-	-
Seed and soil treatment	-	3	-	-	-
Fertilizer	-	3[a]	-	-	-
Intensification of cropping cycle	-	2	-	-	-
Variety x *Rhizobium* inoculation	-	3	-	3	-
Verification	8	11[a]	8	6	3
Farmer-managed	-	8	-	-	16[d]
TOTAL	16	44	14	18	25

a Copy of trial planted on nearby experimental station for comparison.
b 3 VEF and 3 EP in each. 2 EPs planted on farm in other parts of Colombia.
c For training purposes, 3 in El Carmen (relay), 3 in Marinilla (sole crop).
d Simple tests of rows of new varieties within his crop.

Table 3. Comparison between station and farms of an exploratory trial in a 2^4 factorial arrangement. Obonuco and Ipiales, 1982B.

	Obonuco Exp. Station		Mean of 5 farms-Ipiales	
	Beans	Maize	Beans	Maize
Foliar disease control (E)	kg/ha			
Mancozeb (3 times)[1]	573	2134	564	1753
Benomyl + Mancozeb (3 times)	605	2691	877	1587
Increase	32NS	557NS	313***	-166NS
Variety (V)				
Mortiño[1]	479	2278	598	1757
Frijolica 0-3.2	699	2547	843	1582
Increase	220***	269NS	245***	-175NS
Fertilizer (below seed at planting) (F)				
100 kg/ha 13-26-6[1]	605	1888	756	1771
400 kg/ha 13-26-6	574	2937	685	1568
Increase	-31NS	1049***	-71*	-203*
Spatial arrangement (D)				
4 maize 2 beans 1.0 x 1.0m[1]	473	2201	598	1502
2 maize 2 beans 1.0 x 0.5m	705	2625	843	1836
Increase	232***	424*	245***	334***
Interactions significant[2] (P=0.05)	None	VF+	DV+,DE+	None
Interactions significant (0.05=P=0.10)	VF+, EF+	DVF+		None

1 Farmers' practices

2 + indicates that the yield was higher than the sum of the simple effects when both factors were at the researchers' level

Table 4. Comparison between station and farms of a method of fertilizer application trial. Obonuco and Ipiales, 1983 B. Variety Frijolica 0-3.2. A farmers' check with the variety Mortiño was included in the trial, but does not appear in the Table.

			Obonuco Exp. Station				Mean of 2 farms: Ipiales			
kg/ha 13-26-6	Position	Time of applic.	Bean yield (kg/ha)	Bean stand (%)[1]	Maize yield (kg/ha)	Maize stand (%)[1]	Bean yield (kg/ha)	Bean stand (%)[1]	Maize yield (kg/ha)	Maize stand (%)[1]
RP/DAP[2]	Under seed	Planting	1353	75	3297	98	192	20	778	36
500	Banded	Ridging-up	1267	94	2942	85	484	60	1216	61
500	Under seed	Planting	1252	78	2576	85	440	32	1586	64
500	Above seed	Planting	1184	78	2638	95	336	43	1247	46
500	Hole at side	Planting	1148	77	3557	96	445	62	1812	65
500	Side-dressed	Ridging-up	1103	83	2408	91	752	66	1199	67
100[3]	Side-dressed	Ridging-up	1074	70	2553	95	461	64	1263	62
LSD (10%)			186	34	1371	15	247	9	508	16

1 Plants surviving to 8 weeks as percentage of number of seeds planted.

2 446 Huila Rock Phosphate + 79 DAP + 110 Urea + 50 KCl (equivalent nutrients to 500 kg/ha 13-26-6).

3 Farmers' dose and most common method.

Table 5. Comparison between station and farms of a fertilizer trial (3N x 3P levels + 6 additional treatments). Obonuco and Ipiales, 1983 B to 1985 B. Variety Frijolica 0-3.2 for all except the farmers' check.

	Fertilizer applied (kg/ha)	Yield (kg/ha) Obonuco Exp. Station Mean of 3 years		Yield (kg/ha) Ipiales-Mean of 9 farms (3 per year)	
		Beans	Maize	Beans	Maize
Mean of	13N	930	2141	702	1689
P levels	39N	883	2646	627	2074
	65N	884	2674	679	2392
Mean of	11.3P	917	2399	620	2051
N levels	34.0P	884	2430	657	2018
	56.7P	896	2633	731	2086
LSD (10%)		86	263	60	167
Additional treatments					
39N 34P		892	2453	632	2080
39N 34P + 15K		893	2384	739	2119
300 kg/ha 13-26-6		969	2424	688	2096
300 kg/ha 13-26-6 + 20 Mg		1002	2220	706	1869
100 kg/ha 13-26-6 (check)		994	2668	599	1981
0 (without fertilizer)		933	2311	454	1563
Farmer's check (Mortiño with 100 kg/ha 13-26-6)		905	2675	488	1929
LSD (10%)		150	545	106	289

Table 6. Comparison between station and farms of a bean variety x spatial arrangement trial with Morocho Blanco maize. Obonuco and Ipiales, 1984 B. Underlined yields show the most favorable combination for each variety; dotted underlining refers to a minimum row spacing of 0.8m.

Bean variety	Distance between hills (m[1])	Seeds/hill		Yield (kg/ha) Obonuco Exp. stn		Yield (kg/ha) Iplales-Mean 2 farms	
		Beans	Maize	Beans	Maize	Beans	Maize
TIB 30-42	0.5	4	2	1220	1290	1057	1285
TIB 30-42	1.0	4	4	755	1469	762	1116
TIB 30-42	1.0	2	4	606	1737	623	1500
32980-1-41	0.5	4	2	1666	1995	577	1359
32980-1-41	1.0	4	4	1176	1924	515	1387
32980-1-41	1.0	2	4	1008	1905	382	1540
Frijolica 0-3.2	0.5	3	2	1466	1804	821	1327
Frijolica 0-3.2	0.65	3	3	1417	1913	666	1189
Frijolica 0-3.2	0.8	3	3	1139	1673	654	1437
Frijolica 0-3.2	1.0	4	4	1175	2037	653	1401
Frijolica 0-3.2	1.0	3	4	1086	1857	562	1461
Frijolica 0-3.2	1.0	2	4	1226	2071	357	1355
Mortiño (farmers')	1.0	2	4	885	2009	476	1346
LSD (10%)				468	474	115	305

1 Distance between rows always 1.0 m .

Table 7. Comparison between station and farms of a maize variety x bean variety x spatial arrangement trial. Obonuco and Ipiales, 1985 B. Underlined yields show the most favorable combination for each bean variety.

Bean variety	Maize variety	Distance between hills (m)[1]	Seeds/hill		Yield (kg/ha) Obonuco Exp. Stn		Yield (kg/ha) Ipiales-Mean 2 farms[2]	
			Beans	Maize	Beans	Maize	Beans	Maize
TIB 30-42	Pool 7	0.8	4	3	1725	286	670	2122
TIB 30-42	Pool 7	0.8	6	4	1693	546	541	2491
TIB 30-42	Pool 7	0.8	4	4	1528	836	488	2517
TIB 30-42	Pool 7	1.0	4	4	2057	877	375	2140
Frijolica 0-3.2	Morocho Blanco	0.8	4	3	1374	1759	531	2342
Frijolica 0-3.2	Morocho Blanco	0.8	4	4	1022	2174	368	2359
Frijolica 0-3.2	Morocho Blanco	0.8	3	3	1277	1755	308	2191
Frijolica 0-3.2	Pool 7	0.8	3	3	974	1106	321	2059
Frijolica 0-3.2	Morocho Blanco	0.8	3	4	944	2306	286	2306
Frijolica 0-3.2	Morocho Blanco	1.0	3	4	1422	2827	234	2365
Mortiño (farmers')	Morocho Blanco	1.0	2	4	1135	2062	199	2479
LSD (10%)					278	1157	194	748

1 Distance between rows always 1.0m

Table 8. Comparison of bean yields on-station and farms in a verification trial. Obonuco and Ipiales, 1984 B.

Bean variety	Foliar disease control	Yield (kg/ha) Obonuco Exp. Stn	Yield (kg/ha) Ipiales-Mean 9 farms[1]
Mortiño	Farmer's	722	327
Frijolica 0-3.2	Farmer's	716	374
32980-1-41	Farmer's	728	433
Mortiño	Benomyl + mancozeb	831	450
Frijolica 0-3.2	Benomyl + mancozeb	774	445
32980-1-41	Benomyl + mancozeb	871	395
Effect of changing foliar disease control			
Mortiño		109	123
Frijolica 0-3.2		58	71
32980-1-41		143	-38
LSD (10%)		517	68
Mean effect of changing foliar disease control		103NS	52*
Mean effect of varieties			
Mortiño		776	388
Frijolica 0-3.2		745	410
32980-1-41		800	414
LSD (10%) for variety means		366	48

1 11 farms for maize

B. Economics

Economics research in the bean program continues to concentrate on production studies, marketing issues, policy analysis and training. Production studies identify farm level constraints, evaluate new technologies as solutions to these problems, and assess farmer adoption of improved bean technologies. Marketing issues are crucial in Latin America because most beans are produced for sale in the market, making consumer acceptability, price and ease of entry into market channels critical factors in farmer adoption of improved bean varieties. Analyses of policy affecting bean production and markets are undertaken when policies exert an important influence on the environment for which new bean technology is being developed. Most of this research is conducted in collaboration with national programs, and strengthening their research capacity through training and joint projects is a major objective.

Production studies

Several types of production studies were undertaken with national programs in 1986. Diagnostic studies of current production systems and problems were conducted in Brazil, Colombia, Costa Rica, Dominican Republic, El Salvador, Nicaragua and Peru. Pre-adoption studies of farmer acceptance of promising new technologies were in progress in Brazil, Colombia, Guatemala and Peru. Analyses of adoption studies in Costa Rica and Guatemala were furthered to understand the impact and limitations to the spread of new bean technologies. Results of examples of some of these studies will be presented here.

Diagnostic studies: Dominican Republic

In collaboration with the Secretary of State for Agriculture, a diagnostic survey of bean production systems and problems was conducted in three regions in the Dominican Republic: eastern (Higuey), northcentral (La Vega) and central (San Jose de Oca). The results of interviews of 90 farmers have now been analyzed for use in the design of technology trials for these regions (Table 1).

While drought is the most common problem in all three regions and pompadour is the principal grain type, important contrasts exist. In Higuey, where the terrain is flatter, most production is mechanized, and the average acreage sown to beans is greater. Moreover, fertilizer and crop protection chemical use is practically universal in Higuey. Chrysomelids are reported as a major problem in Higuey, while in La Vega *Hedylepta indicata* F. (a leaf feeding caterpillar) is the most commonly cited problem after drought.

Table 1. Characteristics of three bean producing regions in Dominican Republic.

Region	East (Higuey)	Central (S. Jose de Oca)	Northcentral (La Vega)
Farm size (ha)	6	5.8	8.6
Topography	Flat	Hilly	Very hilly
Systems	Maize/Beans; Bean monoc.	Maize/Beans; Bean monoc.	Bean monoculture Beans/Cassava
Crops in rotation	Peanuts	Peanuts, potatoes	Cassava, maize, plantain
Land preparation	Mechanical	Oxen	Oxen
Grain type of beans	Pompadour; reds	Pompadour; blacks	Pompadour
Area of beans (ha/farm)	3.4	1.0	2.7
Fertilize beans (%)	100	30-40	30-40
Crop protection chemicals (%)	90	50	50
Problems	Drought Chrysomelids	Drought Lack of seed	Drought; Leaf feeding caterpillars (*Hedylepta indicata* F.)

[a] *Hedylepta indicata* F.

Source: SEA-CIAT Survey Data. Sample size = 90.

Pre-adoption evaluations

"Gloriabamba" in Peru:

A survey of farmers' acceptance of the recently released climbing bean variety, Gloriabamba (a germplasm accession from Mexico), has been carried out in collaboration with INIPA in the northern highlands of Peru. Farms here average 2.5 ha with 40% of farms less than one hectare. Beans are produced mainly for home consumption in association with maize, also a subsistence crop. Preliminary results from a sub-sample of the 109 farmers interviewed who were known to have received seed of Gloriabamba, found that all farmers plan to continue growing it.

Some farmers have already grown Gloriabamba for two or more years, and the survey data show that farmers are increasing the quantity planted of Gloriabamba over time. Farmers using Gloriabamba for the first time sow an average of 0.8 kg of seed, while in the second year they plant an average of 5.2 kg of seed, and in the third year 10.1 kg of seed. The main advantages of Gloriabamba cited by farmers are its yield, earliness and good taste (Table 2). In farmer production it yields an average of 455 kg/ha compared to 230 kg/ha with the principal local variety, while it is forty days earlier than traditional climbing varieties.

The most common drawback with Gloriabamba noted by farmers is that because of its smaller size it receives a lower price than traditional varieties, confronting a discount of up to 50% at the farm gate. This factor was mentioned only by a minority of farmers (15%) due principally to the fact that beans are mostly consumed on-farm. These results imply that due to its yield Gloriabamba could be widely adopted by subsistence bean producers, while facing a more uncertain future among those producing for the market.

Table 2. Farmer evaluations of improved variety "Gloriabamba", Northern Highlands, Peru (preliminary partial results). 1986.

Characteristic	Percentage of farmers
Higher yielding	77
Earlier	67
Good tasting	26
More disease resistant	18
Lower price	15

Source: INIPA-CIAT Survey Data, sample size = 109.

Adoption studies: Guatemala

Data from a 1985 random sample of 234 bean producers in southeastern Guatemala have been analyzed to assess the impact and spread of new ICTA bean varieties. Among those producers having farms of an average total cultivated area of 2.9 ha, 23.8% are growing the improved varieties on 24.1% of their area in beans. Production functions estimated for these farms show that growing the new varieties makes a substantial (334 kg/ha) and statistically significant impact on production:

$$
\begin{aligned}
(1)\quad YLD = 515 &+ \underset{(4.93)}{334\ VAR} + \underset{(2.19)}{167\ WEED} + \underset{(2.41)}{367\ FUM} + \underset{(6.53)}{4.68\ TOTP} + \underset{(2.19)}{9.88\ TOTK} \\
&- \underset{(4.21)}{122\ FMFS} - \underset{(1.72)}{341\ FMS},
\end{aligned}
$$

$$R^2 = .32,$$

where

YLD	=	Bean yield (kg/ha)
VAR	=	Dummy variable for growing ICTA varieties
WEED	=	Dummy variable for more than one marked weeding
FUM	=	Dummy variable for fungicide application
TOTP	=	P_2O_5 application (kg/ha)
TOTK	=	Potassium application (kg/ha)
FMFS	=	Dummy variable for system maize/beans or sorghum/beans
FMS	=	Dummy variable for system maize/sorghum/beans

The ratio of parameter estimates/standard errors is given in parenthesis ("t" values).

The production function also shows a strong effect of disease control, indicating that disease is an important limiting factor on production. However, there is no statistically significant interaction between the new varieties and cropping system (2), thus indicating that the new varieties have the same impact on yield regardless of system, making the new varieties neutral with respect to system.

$$
\begin{aligned}
(2)\quad YLD = 525 &+ \underset{(2.31)}{291\ VAR} + \underset{(2.22)}{171\ WEED} + \underset{(2.42)}{369\ FUM} + \underset{(6.54)}{4.72\ TOTP} + \underset{(2.21)}{10.03\ TOTK} \\
&- \underset{(1.61)}{132\ FMFS} - \underset{(4.00)}{369\ FMFS} + \underset{(0.19)}{30\ FMFSVAR} + \underset{(0.68)}{132\ FMSVAR},
\end{aligned}
$$

$$R^2 = .32$$

where variables and "t" values are as defined in (1), except

FMFSVAR	=	Interaction of VAR and FMFS
FMS	=	Interaction of VAR and FMS

Since the evidence points to a significant positive productivity impact of the new varieties, it is important to assess what factors have limited their use to less than one-fourth of farmers. An adoption function with use or non-use of the improved varieties as the dependent variable finds two factors as especially important in determining whether farmers cultivate the new variety.

$$(3)\quad ADOP = \underset{}{0.366} + \underset{(8.00)}{0.647\ SEED} - \underset{(1.94)}{0.109\ FASS} - \underset{(4.06)}{0.205\ PREFEAR} + \underset{(1.19)}{0.012\ AREACULT}, \quad R^2 = .34,$$

where ADOP = Dummy variable = 1 when growing ICTA variety
SEED = Dummy variable = 1 when using official seed
FASS = Dummy variable = 1 when beans grown in association with other crop(s)
PREFEAR = Dummy variable = 1 when farmer expresses preference for early varieties
AREACULT = Area cultivated in ha.

Access to official sources of seed is the single most influential variable on whether farmers grow the new varieties, with a strongly positive effect and low standard error of estimate. An expressed preference by the farmer for early maturing beans strongly reduces the probability of adoption of the new varieties. Essentially the same results were obtained when percent of bean area sown to ICTA varieties was regressed on the same set of variables. These findings are highly consistent with, and provide multivariate confirmation of, previous survey work with farmers known to have used (at one time) the new varieties. The previous study had found that difficulty in obtaining seeds of the new varieties led to a rapid decline in their use, while lateness was noted as the principal drawback of the new varieties for farmers. These new results confirm the importance of generation of improved early varieties, and the importance of strengthening the seed distribution system to make the potential gains from the new varieties more widely available.

The adoption models were also used to assess the influence on adoption of socioeconomic factors such as farm size, land tenancy, education of head of household, use of agrochemicals, and credit access. None of these variables were found to be significantly related to adoption.

Based on the survey results on proportion of area cultivated to the new varieties, and using the production function estimate of the yield gains from the new varieties in farmers' production, the value of the increased bean production in 1985 due to the new varieties is an estimated $2,060,000 at world market prices.

Policy

Benefits of technology in Brazil

Some new bean technologies can favor large farmers (eg. varieties bred for mechanization) while others can favor small farmers (eg. varieties adapted to intercropping). Because of a widespread concern that technical change in agriculture not bypass resource poor farmers, it has been argued that research should be oriented to generate technology biased towards small farmers.

To assess the distribution of benefits of alternative technologies biased towards small or towards large farmers, both among producer groups as well as among consumers of different income strata, a demand and supply model of beans has been constructed for Brazil, to measure economic surplus resulting from supply shifting technical change.

The model shows that benefits to small farmers are highly sensitive to the degree of technology bias, since they lose even if technology is only slightly biased towards large farmers, and they lose substantially as technology becomes progressively biased towards large farmers (Table 3). Moreover, benefits to small farmers increase sharply as technology is biased towards them, even in comparison to scale neutral technology. These gains for small farmers come largely at the expense of consumers. Benefits to poor consumers decline drastically as technology is biased towards small farmers, though consumer benefits vary only modestly between scale neutral and large farm technology.

There exists, then, a clear distributional trade-off between benefits to small farmers and poor consumers in small farm biased technology. Though this trade-off does not present itself so strongly with large farm technology, small farmers lose dramatically in this case. Thus, though large farmer technology has little to recommend it, leaving consumers somewhat worse off and small farmers very much worse off compared to scale neutral technology, the sharp equity trade-off between small farmers and poor consumers with small farm biased technology, confronts equity oriented policy makers with a difficult choice.

Training

Visiting economists from El Salvador, Mexico and the Netherlands completed training internships at CIAT, Palmira, while student theses were supervised in Colombia and Guatemala. A special workshop on economic analysis was conducted in Costa Rica, while training in economic survey techniques, survey analysis, and budgeting formed a major part of on-farm research courses conducted in Colombia, Costa Rica, El Salvador, Nicaragua and Peru.

Table 3. Distribution of estimated annual benefits of alternative bean technologies in Brazil (1982 U.S. Dollars x 10^3).

Technical Alternatives	Small farmers	Large farmers	Lowest income consumer quartile	Consumer quartile	Consumer quartile	Highest income consumer quartile	Tot gross social benefits
Strong small farm bias	85.556	-6.434	3.844	3.454	3.454	2.507	92.381
Some small farm bias	60.108	38.328	18.328	16.434	16.266	11.866	161.184
Scale neutral	38.360	76.876	30.862	27.631	27.408	19.887	221.024
Some large farm bias	-568	79.906	29.023	26.015	25.792	18.718	178.976
Strong large farm bias	-46.906	83.561	26.962	24.121	23.898	17.381	129.023

IV. PERSONNEL (December 1986)

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David Allen, PhD, Plant Pathology, Regional Coordinator, Southern African Bean Project (stationed in Arusha, Tanzania).
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APPENDIX I - LIST OF COLLABORATING INSTITUTIONS

CARDI	Caribbean Agricultural Research Development Institute, West Indies.
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.
CDA	Collaboration for Development in Africa.
CENARGEN	Centro Nacional de Recursos Genéticos, Brazil.
CENICAFE	Centro Internacional de Café, Colombia.
CENTA	Centro Nacional de Tecnología Agropecuaria, San Salvador, El Salvador.
CESDA - CENDA	Centro Sur de Desarrollo, Centro Norte de Desarrollo, Dominican Republic.
CGIAR	Consultative Group for International Agricultural Research, New York, New York.
CGPRT	Course Grains, Pulses, Roots and Tuber Crops Center.
CIAB	Centro de Investigación Agrícola del Bajío, México.
CIAGOC	Centro de Investigación Agrícola del Golfo Centro, México.
CIANOC	Centro de Investigación Agrícola Norte Central, México.
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, México.
CIP	Centro Internacional de la Papa, Lima, Perú.
CNP	Consejo Nacional de Producción, Costa Rica.
CNPAF	Centro Nacional de Pequisa em Arroz e Feijao, Brazil.
CIPA	Centro de Investigación y Promoción Agropecuario (I and II), Perú.
CPATU	Centro de Pesquisa Agropecuaria de Trópico Umido, Brazil.

CRSP	Collaborative Research Support Program, Tanzanía
CVC	Corporación Autónoma Regional del Valle y Cauca, Colombia.
DIGESA	Dirección General de Servicios Agropecuarios, Guatemala.
DRI	Desarrollo Rural Integrado, Colombia.
EEAOC	Est. Exptl. Agrícola Obispo Colombres, Brazil.
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brasilia, Brazil.
EMCAPA	Empresa Capichaba de Pesquisa Agropecuaria, Brazil.
EMGOPA	Empresa Goianía de Pesquisa Agropecuaria, Brazil.
EMPASC	Empresa de Pesquisa Agropecuaria de Santa Catarína, Brazil.
EPABA	Empresa de Pesquisa Agropecuaria de Bahía, Brazil.
ESAL	Escola Superior de Agricultura de Lauras, Brazil.
FAO	Food and Agriculture Organization of the United Nations, Rome, Italy.
FEDECAFE	Federación Nacional de Cafeteros, Colombia.
IAPAR	Fundacao Instituto Agropecuario de Paraná Brazil.
IAR	International Agricultural Research.
IARC	International Agricultural Research Centers Network.
IBPGR	International Board for Plant Genetic Resources, Rome, Italy.
ICA	Instituto Colombiano Agropecuario, Colombia.
ICARDA	International Center for Agricultural Research in the Dry Areas, Beirut, Lebanon.
ICTA	Instituto de Ciencia y Tecnología Agrícola, Guatemala. Cita, Guatemala.

IDIAP	Instituto de Investigaciones Agricola Panameñas, Panama.
IICA	Instituto Interamericano para la Cooperación Agrícola, Costa Rica.
IITA	International Institute of Tropical Agriculture, Nigeria
INCAP	Instituto de Nutrición de Centroamérica y Panamá, Costa Rica.
INERA	Institut Nacional des Etudes es Recherches Agrícolas, Zaire.
INIA	Instituto Nacional de Investigación Agrícola, Perú.
INIAP	Instituto Nacional de Investigaciones Agropecuarias, Ecuador.
INIPA	Instituto Nacional de Investigaciones y Promoción Agraria, Lima, Perú.
INRA	Institut Nacional de Recherches Agronomiques, Guadalupe.
INTA	Instituto Nacional de Tecnología Agropecuaria, México.
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina.
INTA	Instituto Nicaraguense de Tecnología Agropecuaria, Nicaragua.
IPA	Instituto de Pesquisa Agropecuaria, Pernambuco, Brazil.
IPAGRO	Instituto de Pesquisas Agronómicas, Brazil.
ISABU	Institut de Sciences Agronomiques du Burundi, Burundi.
ISAR	Institut Scientifique et Agronomique du Rwanda, Rwanda.
ISNAR	International Service for National Agricultural Research, The Hague, Netherlands.
IVT	Institut Veredeling, Tuinbouwgewassen, The Netherlands.

NVRS	National Vegetable Research Station, Costa Rica.
ONS	Oficina Nacional de Semillas, Costa Rica.
PCCMCA	Programa Cooperative Centroamericano de Mejoramiento de Cultivos Alimenticios.
PESAGRO	Pesquisa Agropecuario, Brazil.
SADCC	Southern Africa Development Coordination Conference
SDC	Swiss Development Cooperation, Switzerland.
SEA	Secretaría de Estado de Agricultura, Dominican Republic
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture.
SRN	Secretaría de Estado de Recursos Naturales, Honduras.
UEPAE	Unidad de Execucao de pesquisa de Ambito Estadual, Brazil.
VISCA	Visayas State College of Agriculture, the Philippines.
VICOSA	Universidade Federal de Vicosa, Brazil.