CIAT in the 1980s revisited

A medium-term plan for 1986 to 1990

Centro Internacional de Agricultura Tropical

CIAT is a nonprofit organization devoted to the agricultural and economic development of the lowland tropics. The government of Colombia provides support as a host country for CIAT and furnishes a 522-hectare site near Cali for CIAT's headquarters. In addition, the Colombian Foundation for Higher Education (FES) makes available to CIAT a 184-hectare substation in Quilichao and a 73-hectare substation near Popayán; the Colombian Rice Federation (FEDEARROZ) also makes available to CIAT a 30-hectare farm—Santa Rosa substation—near Villavicencio. CIAT co-manages with the Colombian Agricultural Institute (ICA) the 22,000-hectare Carimagua Research Center on the Colombian eastern plains and carries out collaborative work on several other ICA experimental stations in Colombia; similar work is done with national agricultural agencies in other Latin American countries.

CIAT is financed by a number of donors, most of which are represented in the Consultative Group on International Agricultural Research (CGIAR). During 1985 these CIAT donors include the governments of Australia, Belgium, Brazil, Canada, France, the Federal Republic of Germany, Italy, Japan, Mexico, the Netherlands, Norway, the People's Republic of China, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. Organizations that are CIAT donors in 1985 include the European Economic Community (EEC), the Ford Foundation, the Inter-American Development Bank (IDB), the International Bank for Reconstruction and Development (IBRD), the International Development Research Centre (IDRC), the International Fund for Agricultural Development (IFAD), the Rockefeller Foundation; the United Nations Development Programme (UNDP), and the W. K. Kellogg Foundation.

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BEAN PROGRAM

Introduction

The common, dry or field bean *(Phaseolus vulgaris* L.), which is the most important grain legume species for direct human consumption in the world, contains about 25 percent protein. Beans are a traditional food for the lower income strata in Latin America, particularly in Brazil, Mexico, Central America, the Andean Zone and some Caribbean countries. The highest per capita consumption in the world is in Eastern Africa, especially in Rwanda, Burundi and the Kivu region of Zaire. Other important bean-producing countries are Kenya, Malawi, Tanzania, Uganda, Turkey and Iran. Primarily a small-farmer crop, beans are grown in a wide range of cropping systems, where few purchased inputs are used and yields are generally low. Not only has production growth in Latin America been less than half that of population growth over the last decade; but also yields, currently averaging about 550 kg/ha, have declined in some major producing countries.[36] Although area expansion has allowed a slight production increase in most countries, it has not kept pace with population growth, much less with demand. Latin American net imports reached a record level of 400,000 t/year in the 1980-1982 period. Brazil, Costa Rica, Cuba and Venezuela have been traditional importers; only Argentina and, to a lesser extent, Chile have been net exporters, mainly to Europe. In some countries (e.g., Mexico and Colombia) where long-term active bean research programs exist, national average yields have tended to increase. Encouraging trends are also evident in Guatemala and other Central American countries, as well as in Argentina.

Similarly, in about half the countries in Africa for which adequate data exist,[37] bean production growth rates have been at least 1 percent per annum less than population growth. Yield trends have been stagnant, and any production growth has been obtained through area expansion. In many countries, including Rwanda, Burundi and Kenya, land

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[36] **Trends in CIAT Commodities,** Internal Document, Economics:1.8, CIAT, March 1983, 163p.

[37] D. Pachico and W. Calderon, **Bean consumption in Sub-Saharan Africa: a preliminary review,** in **Trends in CIAT Commodities,** CIAT Internal Document, Economics: 1.9, April 1984.

suitable for bean production is already limited. An estimated 110 million people in sub-Saharan Africa live in countries where beans are the leading source of noncereal protein; thus an apparent decline in per capita bean consumption since the early seventies may be having a critical impact on protein nutrition in those areas due to the prominence of beans in the diet. Bean prices have tended to increase more rapidly than general inflation in many countries; however, there is no long-term trend as prices are highly variable. In Brazil, for example, real prices of beans tripled between 1972 and 1976; halved by 1978-1979, only to double again in 1980; and halved again by 1982.

Regardless of increased market prices, bean production is characterized by low profitability and high risk. Low and unstable yields, together with seasonal climatic variability and consequent seasonal price fluctuations, have led increasingly to the displacement of beans in traditional areas by higher value crops or crops with a more predictable price structure. In Brazil, for example, soybeans have displaced beans on more fertile soils. Bean productivity continues to decline after moving to marginal soils with lower fertility. A similar situation has occurred in Mexico, where increased sorghum production may have been the competitive influence.

Selected commercial bean varieties, grown under experimental conditions with appropriate plant protection and irrigation, are capable of far higher yields than those seen in national production statistics. Experimental bush bean (monoculture) yields of 3 to 4 t/ha in a 90-day crop season are not uncommon. At CIAT, experimental yields of climbing beans grown on artificial supports (monoculture) have exceeded 5 t/ha in 100 days. The large yield gap that exists between farm and experimental situations could be reduced substantially by using improved varieties and production technology. Economic analyses have indicated that if production in Latin America were to increase 5% annually over the next five years, the additional production would be absorbed by increased consumption, with an average price decline of only 3%.[38]

[38] Trends in CIAT Commodities, 1983, op. cit.

Program History and Accomplishments

Formation of a coordinated program focusing only on *P. vulgaris* dates from 1973. The establishment of the world *Phaseolus* germplasm collection, currently containing some 35,000 accessions, forms the base for sources of resistance to major diseases and pests. Assistance is received from the Genetic Resources Unit, which provides the sources of genetic variability; and from the Food and Nutrition Laboratory, which monitors nutritional and consumer preference characteristics of advanced materials.

The breeders carry out more than 1500 crosses (parental combinations) yearly. Breeding populations (F_2 and F_3) are first evaluated for disease and insect resistance, architecture and consumer requirements.In the second stage, all bean scientists are involved in the testing of selections in successive uniform nurseries to confirm disease and insect resistance and general adaptation at two altitudes. In the third stage of evaluation, the materials are selected for the above characters, as well as for nitrogen fixation, water stress tolerance, low phosphorus tolerance, resistance to minor diseases, protein content and cooking time. From 200 to 300 new advanced lines are evaluated yearly for their yield performance under stress and nonstress conditions at three sites in Colombia. These lines are then made availabe as parental sources to national bean programs.

Approximately one hundred superior lines enter the IBYANs (International Bean Yield and Adaptation Nurseries) each year. As national programs increase their capability to undertake breeding and selection activities, their entries will form part of this program. More than 150 IBYAN trials are shipped yearly to bean-producing countries in Latin America, the Caribbean and other parts of the tropics and subtropics.

Selected highlights of the program are as follows:

1. All lines leaving the second stage of evaluation are resistant to BCMV (Bean Common Mosaic Virus).

2. Multiple-disease resistant germplasm is now being distributed for international testing. Lines resistance to all known races of anthracnose have been identified.

3. Tolerance to drought, extreme temperatures, all major diseases and pests, high aluminum and low phosphorus in the soil has been identified, with maturity differences appropriate for different production systems.

4. Yield levels of small, nonblack-seeded experimental lines have been improved significantly and are now equal to or surpass yields of the initially superior black-seeded germplasm.

5. Lines developed collaboratively with the Instituto de Ciencia y Tecnología Agrícolas (ICTA) in Guatemala for tolerance to BGMV (Bean Golden Mosaic Virus) outyielded leading commercial varieties under heavy disease pressure, even when susceptible local lines received heavy insecticide applications. Chemical protection further increased yields of resistant lines.

6. Over twenty lines originating from collaboration with national breeding programs are now being evaluated at the farm level or are being multiplied for seed by national programs in Latin America and the Caribbean. Disease-resistant lines have been released in several countries.

7. Improved agronomic practices have increased yields 50 to 100% in numerous experiments in Colombia. An inexpensive, nontoxic farm-level storage technology employing vegetable oils has also been adapted to beans; diffusion of this technology has begun in Colombia.

8. Through 1984, 529 national program scientists have received training at CIAT, mainly in bean production short courses or intensive discipline-oriented training.

Production Systems

In the tropics and subtropics of Africa and Latin America, bean production tends to be concentrated at intermediate and high altitudes in areas with high rural population densities. A series of cropping

systems have evolved as small farmers adjusted to various environmental and socioeconomic constraints. The four major cropping systems[39] can be classified as follows:

1. **Bush beans in monoculture.** This system is common in low- to medium-altitude areas, chiefly in Brazil, Argentina, Chile, the Dominican Republic, Kenya, Mexico, Peru and Turkey.

2. **Bush, semiclimbing and climbing beans in relay systems with maize.** The relay system is mainly found in low to intermediate altitudes of Colombia, Central America and Southern Africa.

3. **Bush beans in direct association with maize.** This system where maize and beans are usually sown at the same time is common in intermediate altitudes in Colombia, Kenya, Tanzania, Zambia, Venezuela, and in many areas of Brazil.

4. **Climbing beans in direct association with maize.** The system is found in higher altitudes (2000 masl) of Burundi, Rwanda, Colombia, Ecuador, Guatemala and Peru, as well as in northern Turkey.

Maize, which predominates as a companion crop in these systems, is a major constraint to increased bean production. Most studies show bean yield reductions of about 50 percent in associated systems with maize. It is obvious that the total return from the two crops in the system is more important for farmers than the individual components.

Data on bean production microregions are being collected by the Agroecological Studies Unit for Latin America to provide an accurate assessment of the relative importance of the various systems and their production problems. This effort is complemented by on-going economic impact studies.

Data obtained thus far on the Latin American bean microregions have been used to classify growing season climates (Table 6) on the basis of average growing season temperature and water balance conditions.

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[39] D. R. Laing, P. G. Jones and J. H. C. Davis, **Common Bean** *(P. vulgaris)*, In: P. R. Goldsworthy and N. M. Fisher (Eds.), **The Physiology of Tropical Field Crops**, Wiley and Sons, London, pp. 305-351.

Table 6. Classification of bean production zones in Latin America.

Type	General description of climatic zone	Mean growing season temperature[a] (ºC)	Range in mean daily growing season water balance (WB)[a] (+ mm/day)	Latin American production zone ('000 tons)	(% total)
A	Average temperatures and adequate mean seasonal WB	22	-1.5 to 90.4	661	17
B	Average temperatures and slight excess in WB	23	90.4 to 94.0	118	3
C	Average temperatures and large deficits in WB (irrigated areas)	23	-5.6 to -5.1	528	14
D	Average to moderately low temperatures with possible deficit in WB toward end of the growing season	20	-2.7 to - 1.6	1672	42
E	High temperatures with possible deficit in WB toward end of growing season	26	-4.1 to -0.3	262	6
F	Moderately low temperatures and moderate water stress	16	-2.3 to -1.9	451	11
G	Low temperatures and adequate mean seasonal WB	13	-.09 to -.05	45	1

a Mean of conditions in microregions constituting each production zone; overall 110 microregions defined.

Each of the seven zones represents a group of diverse microregions wit similar mean climatic conditions during the actual bean-growin season. The data suggest that most beans (76%) in Latin America ar produced at temperatures close to optimum for the species (20-23ºC) This surprising tendency for production to take place within a narrov temperature range indicates the relatively high sensitivity of the specie to temperature. At the same time, 73 percent of the total productio occurs in microregions having moderate to severe mean water deficits a some time during the cropping season; but very little of this productio is irrigated. Serious water deficits are, therefore, a major productio constraint.

Similar data are being collected in eastern and southern Africa tc increase understanding of production problems, to determine similarities/differences with respect to the Americas, and to realign research priorities where necessary.

Constraints to Increased Production

Of the major world crops, beans are undoubtedly one of the most susceptible to diseases and insect attack. Drought and infertile soils also contribute to low yields.

In most production areas, diseases and pests are the most common important constraints to increased production and productivity. More than 200 pathogens can affect bean productivity. The more prevalent diseases in the western hemisphere are bean common mosaic virus (BCMV), bean rust *(Uromyces phaseoli)*, anthracnose *(Collectotrichum lindemuthianum)*, angular leaf spot *(Isariopsis griseola)*, and common bacterial blight *(Xanthomonas phaseoli)*. In some years web blight *(Thanatephorus cucumeris)* and bean golden mosaic virus (BGMV) are also severe in certain locations. In Africa bean-production constraints from diseases appear to be similar to those in Latin America, which is the center of origin of beans. Insects and virus diseases in Africa are thought to be relatively more important than in Latin America; and fungal and bacterial diseases relatively less important although they cause severe crop losses in many areas.

Most of the commonly utilized cultivars in both continents are not resistant to the major diseases, showing, at best, a low level of tolerance.

Each of these diseases can cause yield losses as high as 80 to 100%. The transmission of BCMV, anthracnose, angular leaf spot and bacterial blights through infected seed has facilitated the spread of these diseases from one region to another.

Among the insect pests, leafhoppers *(Empoasca* spp.) and pod weevils *(Apion godmani)* are the most significant. Leafhoppers have reduced yields of highly susceptible varieties by as much as 90%; and reductions of 20 to 50% are common on many farms even when insecticides are used. Storage insects such as *Zabrotes* and *Acanthoscelides* inflict heavy losses in stored beans; thus farmers are forced to sell their harvest quickly, which contributes to postharvest price declines. The most common insect problem in Africa is the bean fly *(Ophiomya phaseoli)*, which causes severe yield losses, especially under dry conditions. Storage insects and aphids are also believed to be more important in Africa than in Latin America.

Physiological defects of currently utilized cultivars (mostly landraces) contribute to low and unstable bean yields. Many cultivars have a poor plant type so that pods come in contact with the soil at maturity, increasing the possibility of attack by soil-borne pathogens, which results in poor-quality seed. Cultivars with a determinate bush habit are characterized by early and intense flowering, which contributes to low and unstable yield. These cultivars show little ability to compensate for low sowing densities, common on most small farms, and have no mechanism for renewed flowering when stress is relieved. They are grown extensively, however, because of their erectness, earliness and preferred grain type.

Soil-related constraints become important as bean production is increasingly being carried out on more marginal land, characterized by soil acidity and high phosphorus fixation. Associated aluminum toxicity reduces root development and increases sensitivity to water deficits. Nitrogen deficiency is also a limiting factor in many soils where beans are grown; this is complicated by a low capacity for nitrogen fixation in most currently used cultivars. These problems may be more severe in Africa than in Latin America.

All the major environmental and biological constraints to increased bean production can be researched. At the national program level, limited progress has been made toward resolving the problems through new technology because of lack of continuity in research, use of a narrow germplasm base, lack of efficient research methodologies, and insufficient training and information exchange. Those countries with strong national research programs have made considerable production progress, confirming the potential for crop improvement through research.

Program Objectives

The overall goal of the Bean Program is to collaborate with national research efforts to increase and stabilize bean production by conducting research on the principal production constraints. The Program's specific objectives are as follows:

1. To develop—in collaboration with national research institutions—improved technology for beans, which will lead to increased national production and productivity in those countries where the crop is an important food source.

2. To strengthen existing national bean research programs selectively through training and the establishment of a bean research network of collaborating scientists.

In general, production constraints in Latin America appear to be quite similar to those in Africa although they are probably more serious in Africa. Much of the research carried out in Latin America is applicable to Africa and vice versa, but a concerted region-specific research effort will be required on both continents; e.g., on bean flies and improvement of varietal mixtures in Africa and on BGMV and web blight in Latin America.

Recognizing the magnitude of the task, the Program has always sought to delineate its range of activities and to concentrate on those areas where it has a comparative advantage. Thus the program has refrained from conducting research aimed at (a) the humid lowland tropics, where disease pressure is excessive; and (b) the highly acid, infertile soils of the agricultural frontier in the Americas, where bean production would be possible only with massive soil amendments. Moreover, the Program has confined its activities to *P. vulgaris* despite pressure to work with other grain legumes such as lima beans *(P. lunatus)*, cowpeas *(Vigna unguiculata)*, or soybeans *(Glycine max)*. Research in other closely related *Phaseolus* species such as *P. coccineus* and *P. acutifolius*, which are of far less importance in human nutrition, has been confined to the study of characteristics likely to lead to genetic improvement in *P. vulgaris*. Germplasm of the other three cultivated species of *P. phaseolus* are maintained in the GRU (Genetic Resources Unit), accessions of which are made available on request.

General Research Strategies

In order to accomplish the broad objective of increased production, the Bean Program focuses primarily on two basic strategies:

1. Genetic improvement of germplasm.
2. Training of national program scientists to develop a strong collaborative network.

Other complementary activities include the development of agronomic practices and collaboration with institutions in the developed world.

Genetic Improvement

CIAT has been assigned the world responsibility by the CGIAR to collect, evaluate, conserve and distribute *Phaseolus* germplasm. The Bean Program's genetic improvement activities find their strength in the world collection comprised of more than 35,000 accessions of *Phaseolus*, held in the GRU, which distributes these materials to collaborators worldwide. Collection expeditions are organized in collaboration with the IBPGR and national programs to complement this collection where necessary. The collection contains the four cultivated species, wild and ancestral forms, and other *Phaseolus* species.

The Bean Program has placed major emphasis on reducing losses from production constraints through genetic solutions, rather than seek technologies based on increased inputs. Initial emphasis has been on breeding for increased resistance or tolerance to diseases and insects. Continuation of this activity is expected throughout the eighties, but emphasis will gradually shift as national programs share responsibilities and become stronger through training. Diseases and pests are evolving biotic production constraints that will continue to require research inputs; nevertheless, time and resources are expected to be freed from primary focus on disease and insect resistance. They will be used to shift to greater emphasis on improvement of other germplasm characteristics, principally yield potential, tolerance to drought, and important soil-related constraints, particularly low phosphorus availability. As a long-range strategy the improved ability to fix nitrogen biologically will be incorporated in desired germplasm. Such germplasm will be made available in a wide range of maturity classes.

Included in this genetic improvement strategy is the improvement of the basic plant type and yield potential. Improvement of yield potential will first be sought under high-input conditions, but eventually the program seeks to combine increased yield potential with multiple disease resistance.

Development of Collaborative Research Networks

Inadequate training of national bean research scientists and lack of bean research and production information have traditionally been cited as among the main reasons why research in beans has not led to increased productivity. The program places heavy emphasis on strengthening national program research through training at various levels, information exchange and collaborative research.

Initially, training concentrated on awareness training, followed by discipline-oriented training, with heavy emphasis on plant breeding and plant protection. It gradually became apparent that lack of research leadership was a constraint to national program development; therefore, increased attention in training will be given to development of research leadership in national programs through the eighties. The efficiency of trained scientists is greatly magnified by proper research leadership. With new technology increasingly available to national research programs, training in on-farm research (OFR) methodologies and technology transfer methodologies, mostly through CIAT-supported in-country courses, will be increasingly emphasized. Although many research results are obtained currently from experiment stations, the on-farm testing and resulting promotion of the new technology is sought through such training effort. OFR at CIAT is mainly conducted to provide feedback to the research process and will further increase knowledge of bean micro-production regions. However, given the wide and variable target area, CIAT cannot fulfill this function alone; thus a major effort is devoted to training national programs in OFR methodology. The program will interact strongly with other IARCs in this area, especially CIMMYT. Discipline-oriented training is expected to concentrate on "maintenance," mostly following staff turnover or for countries just initiating bean research.

Continued emphasis will be placed on decentralized genetic improvement capitalizing on local adaptation and training. This will strengthen the collaborative bean research network and the individual national research teams which form the network. The Program will increasingly concentrate on solving second generation problems, which are particularly difficult to resolve, as well as on research methodology improvement.

As mentioned previously, beans are produced under a wide range of climatic conditions and cropping systems, each with a particular set of production constraints. Superimposed upon this is the region-specific grain type preferences. Only through a decentralized genetic improvement and training program, in which fully developed national programs assume a large part of the research responsibilities, can increased production be realized. The Bean Program increasingly provides early generation materials or makes crosses requested by national programs, from which varieties will be extracted locally. CIAT complements this decentralized genetic improvement scheme by providing: (a) a research team of highly trained scientists to back up the network; (b) the germplasm bank, with its wide range of genetic variability; (c) a massive hybridization program involving these accessions and national cultivars; and (d) the potential to grow four crops cycles per year, thereby advancing generations more rapidly to stages in which local selection is preferable. CIAT has the infrastructure to screen such germplasm efficiently for resistance in early stages for the principal widespread production constraints (e.g., BCMV, rust, anthracnose, bacterial blight, leafhoppers, drought, low soil fertility, etc.) according to the destination of the materials. Such highly variable, but multiple-factor tolerant material is then provided to national programs for selection for local adaptation, resistance to local diseases, etc. The outreach strategy to Africa is based on this principle. The implementation of such a scheme will be a continued challenge for the Bean Program throughout this decade.

The ultimate aim is to help country programs become full and equal partners in the network. CIAT should assume in the long term a research backstopping role. The speed at which this progress occurs will vary considerably among countries, and some attrition is to be expected. The situation in Africa is particularly critical, where large food shortages occur and national research programs are young. During this and the next decade, heavy emphasis will be placed on developing an effective research network in Africa.

Program Evolution

As a result of the aforementioned developments, the second half of this decade will see progressive changes in priorities in the Bean Program's breeding activities, and some change in overall staffing pattern is anticipated. Figure 7 shows the relative emphasis the Program will place on various aspects of technology development through the decade of the eighties. Changes in emphasis will be reflected in the proportion of crosses in the breeding projects designed for specific groups of constraints.

Substantial variation in plant architecture and disease resistance have been obtained in the breeding and germplasm lines developed since 1976. Plant characteristics associated with higher yield are being sought and, once obtained, should permit development of lines possessing both improved yields and multiple disease resistance. Figure 7 reflects the increasing emphasis to be given to bean plant architecture and yield potential. Work on the improvement of snap beans is also planned during the decade; the Program's degree of emphasis will depend on the outcome of an economic study to determine the importance of snap beans in developing countries and the constraints to increased production and productivity of this vegetable crop.

With most fertilizer prices rising rapidly and the unavailability of credit for small farmers limiting the use of purchased inputs, future elite lines

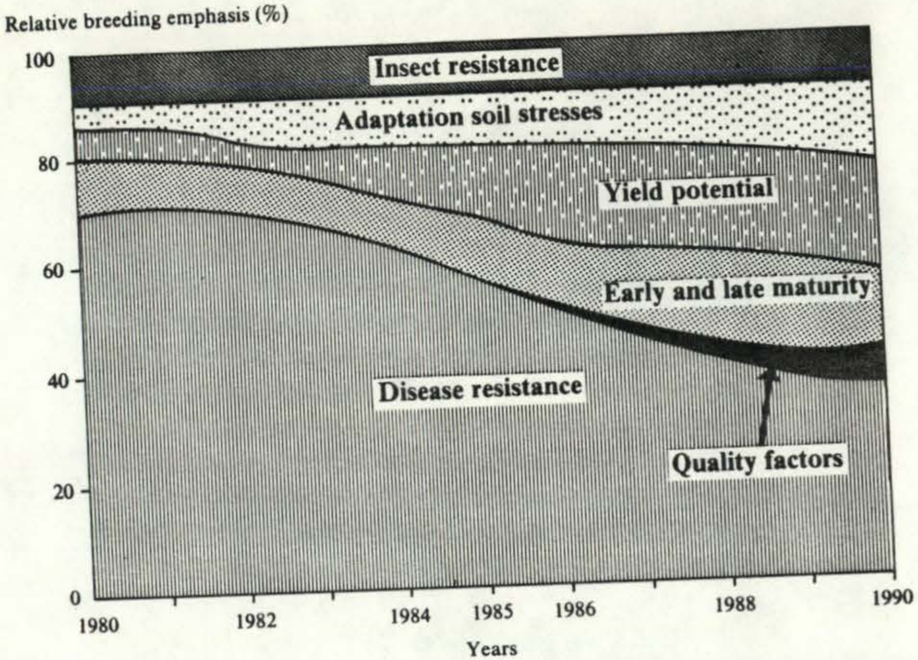

Figure 7. *Evolution of the Bean Program's relative breeding emphasis from 1980-85 and projections for the next 5 years, 1985-90.*

will have to be tolerant to important soil constraints. For regions such as Brazil, Venezuela and many parts of Africa, the Program will need to develop varieties tolerant to moderate soil acidity and low soil phosphorus, which is often associated with drought. Increased capacity for nitrogen fixation is also of critical importance. Incorporating these traits into agronomically acceptable cultivars will require the application of innovative research and research methodologies in soil science, microbiology and physiology to future breeding efforts.

Obviously, the increasing capability of national bean programs will influence the scope and direction of CIAT's research. Training and network activities have helped to build several strong national bean research programs that are capable of developing their own varieties. CIAT should increasingly assume a backstopping role for these programs, providing them with specific genetic variability for their improvement programs, postgraduate training opportunities and documentation support. This would permit more detailed assistance to smaller programs whose breeders, agronomists and pathologists could become more involved in evaluating collaborative breeding nurseries locally to exploit specific adaptation. Problems of nutrition and consumer preference will also receive attention. The program expects to continue to produce some finished experimental lines into the next decade, as many smaller national programs may not be selfsufficient in the generation and selection of segregating materials.

As the program evolves, the bean germplasm bank in the GRU will be used continually as a source for new variability. New collections will be made during the eighties to add genetic variability from regions that are poorly represented at present or from areas where specific desired variability is most likely to be found. Collaboration with the IBPGR in these collection activities will ensure that sufficient resources will be devoted to this important task.

The CIAT Seed Unit is expected to help in the formation of a strong seed industry in Latin America to promote and make available newly developed germplasm. The Seed Unit will pay particular attention to the problem of seed production for the small-farm sector. A seed unit for Africa is presently under discussion by a donor agency. These developments could have an important influence in the availability of bean seed and expedite the adoption of the new varieties by farmers on both continents.

Staffing Projections

Headquarters-Based Staffing Requirements

To achieve the program's objectives and to allow the outlined strategies to be implemented, the program projects the following staffing needs from core funding, corelike projects and special projects. A summary of staffing projections for the period 1986-1990 is shown in Table 7.

Breeding

Genetic improvement responsibilities are divided among the three projected headquarters-based breeders to serve the Bean Program through the 1980s. Large differences in grain-type requirements, growth habit, cropping system and growing environments were the basis on which the assignment of these breeding responsibilities were made. Each grain type is produced under particular ecological conditions and has its specific varietal requirements for disease resistances, yield potentials, cropping system, etc. The main responsibilities of the three breeders are divided as follows:

Brazil, Central America, the Caribbean and Coastal South America. Breeding for these areas includes black-seeded bush and climbing beans generally grown in areas where high temperature adaptation is required such as in Brazil, Central America, the Caribbean and coastal South America; the yellow- and white-seeded types for coastal Peru, Chile and Mexico; the Central American small reds and Caribbean mottled-grain types. BGMV, rust, common bacterial blight and web blight are particularly severe disease problems, which will require continued research attention, as no sources of good resistance are available.

Mexican Central Plateau, Brazil, Argentina and Middle East. The grain types grown in these areas include the bayo, cream and pink types of the Mexican Central Plateau, the nonblack grains of Brazil (e.g., mulatinho and carioca), and the large white-seeded types important in Argentina, North Africa and West Asia. Anthracnose, angular leaf spot and virus diseases (yellow mosaic and bean chlorotic mottle) and acid and salty soils are the principal constraints. In this respect the virus problems are a particularly critical challenge.

Andean Highlands and Eastern and Southern Africa. The grain types for these regions are generally large red (often mottled) and other large light-colored seeds in both bush and climbing growth habits. Anthracnose, ascochyta leafspot (for which no resistance sources are available in beans), halo blight, BCMV, bean flies, low temperature and infertile soils are important production problems. Farmers in the Andean region and in Africa are among the most disadvantaged bean producers because their plots are very small and the soil is infertile; thus production increases must be achieved mainly through an increase in productivity.

As mentioned before, each of these breeders has a decentralized genetic improvement approach, in which multiple-factor bulk segregating

Table 7. Actual senior staff positions in the CIAT Bean Program for 1980-85 and projected positions for 1986-1990 from core funding (CF), corelike (CL) and special projects (SP).

Positions	Funding source	80	81	82	83	84	85	86	87	88	89	90
Headquarters based												
Leader	CF	-	-	-	-	-	1[a]	1	1	1	1	1
Economist	CF	1	1	1	1	1	1	1	1	1	1	1
Breeder	CF	1	1	1	1	1	1	1	1	1	1	1
Breeder	CF	1	1	1	1	1	1	1	1	1	1	1
Breeder	CF	1	1	1	1	1	1	1	1	1	1	1
Agronomist (OFR)	CF	1	1	1	1	1	1	1	1	1	1	1
Agronomist (Int. trials)	CF	1	1	1	1	1	1	1	1	1	1	1
Agronomist (Soils)	CF	b	b	b	b	b	b	b	1	1	1	1
Physiologist	CF	c	c	c	1	1	1	1	1	1	1	1
Pathologist	CF	1	1	1	1	1	1	1	1	1	1	1
Virologist	CF	1	1	1	1	1	1	d	d	d	d	d
Microbiologist	CF	e	e	e	e	1	1	1	1	1	1	1
Entomologist	CF	1	1	1	1	1	1	1	1	1	1	1
Decentralized regional programs												
Central America & Caribbean												
Reg. Coord./Virologist	CF	1	1	1	1	1	1	1	1	1	1	1
Agronomist	CF	1	1	1	1	1	1	1	1	1	1	1
Breeder	CF	1	1	1	1	1	1	1[f]	-	-	-	-
Brazil & Southern Cone												
Reg. Liaison/Agronomist	CF	1	1	1	1	1	1	1	1[f]	1	1	1
Eastern Africa												
Reg. Coord./Pathologist	CL	-	-	-	-	1[g]	1	1	1	1	1	1
Breeder	CL	-	-	-	-	-	1	1	1	1	1	1
Agronomist	CL	-	-	-	-	-	1	1	1	1	1	1
Economist	CL	-	-	-	-	-	1	1	1	1	1	1
Central Africa (Great Lakes)												
Reg. Coord./Breeder	CL	-	-	-	1[h]	1	1	1	1	1	1	1
Anthropologist	CL	-	-	-	-	-	1	1	1	1	1	1
Pathologist	CL	-	-	-	-	1	1	1	1	1	1	1
Southern Africa												
Coordinator (Africa-wide)	CF	-	-	-	-	-	-	1[i]	1	1	1	1
Breeder	CL	-	-	-	-	-	-	1	1	1	1	1
Agronomist	CL	-	-	-	-	-	-	1	1	1	1	1
Entomologist	CL	-	-	-	-	-	-	1	1	1	1	1
North Africa & West Asia												
Reg. Liaison/Agronomist	SP	-	-	-	-	-	-	1[j]	1	1	1	1
Total Headquarters		9	9	9	10	11	12	11	12	12	12	12
Total Decentralized		4	4	4	5	7	11	16	15	15	15	15
GRAND TOTAL		13	13	13	15	18	23	27	27	27	27	27

a **Leader.** The full-time coordinator position was created in 1985 following the EPR 1984 recommendations.

b **Agronomist (Soils).** This position was transferred to Brazil as a liaison function with (and partially funded by) EMBRAPA during the period 1980-86 and will be reinstated at headquarters in 1987 to continue strategic research on problems of soil adaptation in beans.

c **Physiologist.** This position remained unfilled during the period 1980-82 because of financial limitations.

d **Virologist.** This position will move to the Biotechnology Research Unit in 1986, following recommendations of the EPR 1984.

e **Microbiologist.** This position remained unfilled during the period 1980-83 due to financial restrictions.

f **Breeder (Central America).** This position is projected to terminate in 1986 when the functions of the breeder in this core-funded regional project (transferred special project funded by SDC) become a normal part of national program evolution in the region.

Regional Liaison (Brazil and S. Cone). This position was previously filled by the secondment from headquarters of the Soils Agronomist to EMBRAPA. In 1987 it is projected to fund this position fully, following the phasing out of the breeder position in the Central American Regional Project.

g **Regional Coordinator (Eastern Africa).** The first appointment to the Eastern Africa Regional Program was made on this corelike project funded by USAID/CIDA in 1984; the three others are expected during 1985.

h **Regional Coordinator (Great Lakes).** The first appointment to the Great Lakes Project was made in late 1983 on this corelike project funded by SDC (Switzerland); and the full staff complement of three positions plus two associate staff is now in place.

i **Regional Coordinator (Southern Africa).** A corelike project is presently under negotiation with CIDA and the SADCC countries. The four positions should come aboard in 1986 and 1987. CIAT has placed one of these positions, that of Africa-wide coordinator, on the forward list for core funding in 1986.

j **Regional Liaison (N. Africa and W. Asia).** This project is under negotiation with donors; funds should be available on a special project basis in 1986 or 1987.

hybrid populations or advanced lines are provided to national programs, depending upon their strength and requests.

Additionally, the breeders have the responsibility for developing high levels of character expression in a variety of grain types. High and stable parental sources are developed for resistance to rust, storage insect pests, nitrogen fixation, earliness and lateness, etc. Such materials with high character expression are subsequently used as parents for varietal improvement by all breeders. An active interchange of germplasm with the gene bank and among the breeders is noteworthy and is an essential part of the breeding strategy in order to avoid duplication of efforts.

Pathology

Development of lines resistant to diseases for which only low levels of resistance have been identified and recombining several of these in one line will continue to be a challenge into the next decade. Diseases in general will remain one of the most important production constraints and will therefore continue to receive attention in research. The pathologist's input for developing multiple-resistant material is essential. Because of the wide variation in diseases and disease race complexes, training national program scientists and backstopping genetic improvement by inoculation and resistance screening methodology will continue to be needed well beyond this decade. As multiple-resistance germplasm becomes increasingly available, more time will be dedicated to developing integrated disease control strategies.

Physiology

Bean physiology research has slowed in recent years following several years of temporary staff vacancy imposed by budgetary constraints. As benefits from increased levels of disease resistance have been realized, demand for lines with improved physiological characteristics has become increasingly apparent. Increasing yield potential, in early- and especially in late-maturing lines, as well as drought tolerance, will continue to be important research activities of the physiologist. Greater insight into the problems of adaptation (including photoperiod and temperature response) will lead to a better understanding of bean phenology across environments and will guide breeding and agronomic improvements.

Virology

The common bean is highly susceptible to a wide range of plant viruses, most of which have several known strains and can be seed borne. The appearance, for example, of BCMV and BYMV necrotic strains over the last five years has required a drastic modification of breeding strategies. In Africa, the monogenic dominant resistance gene, so effectively exploited in Latin America, is broken down readily because of the predominance of a necrotic strain of BCMV on that continent. Additionally, the complex of viruses (BYMV, BClMV, BGMV), which cause severe crop losses in Argentina, Brazil and the Middle East, will continue to require a strong virology input on the team well into the next decade. It is believed that this research is best provided by transfer of this virology position to the Biotechnology Research Unit. This centralized virology pool can share equipment and resources more rationally. Transfer of this position to the BRU is projected for 1986.

Entomology

Ongoing projects to develop resistance to leafhoppers, bean pod weevil and bruchids will continue through the decade, as gradual but slow progress is expected in the development of multiple-insect resistance. Additional requirements for resistance breeding for the leading bean pests in Africa, such as the bean fly and aphids, and the Mexican bean beetle in Mexico will place a high demand on the entomologist in the future.

Economics

As new technology reaches farmers in many countries, economic studies have been initiated on its impact and limitations, initially at the producer level, and will expand as more countries experience technical changes in production by adopting new technology. These studies also generate further information on production constraints and, in addition to consumer preference studies, help refine the program's minimum input strategy, define varietal characteristics needed by farmers, and provide information for the microregion data base. Case studies are undertaken to assess how government policies affect farmer incentives to use new technology. A study has been initiated on the importance of snap beans, as suggested by the External Program Review (EPR), prior

to further development of the current limited work on snap bean improvement. The economist continues to support OFR, collaborating with the cropping systems agronomist both in methodology development and training. Specific contributions from the economist include target area description and diagnoses, as well as socioeconomic analyses of trial results.

Cropping Systems Agronomy

Research in beans at the national program level is usually conducted on research stations; thus farmer participation in technology development is inadequate in most countries. The Cropping Systems Agronomist will continue to develop the recently initiated network for OFR to feed back information on new technology to the research scientists and then feed it forward to extension personnel. A strong training component is essential in this work, as well as a methodology development research program, initially based in Colombia, to be expanded later during the decade into Central America and Africa in collaboration with the cropping systems agronomists located at the decentralized regional programs.

Agronomy/Soil Science

This position, which was transferred to Brazil in 1979, continues to be needed as a CIAT-Brazil and Southern Cone liaison scientist. With the advent of the recent expansion into Africa, where soil fertility is more limiting, the Bean Program plans to reinstate this position at headquarters in 1987 in order to develop and improve the screening methodology for tolerance to low soil phosphorus and to low soil fertility in general. Additionally, the role of phosphorus and mycorrhiza in fertilizer use efficiency and nitrogen fixation will require the support of this scientist. In the second part of this decade, this research will become increasingly important as better nitrogen-fixation capacity becomes available in bean germplasm.

International Trials Agronomist

Since the formation of the IBYAN in 1976, this agronomist has been in charge of these trials. Up to 1981 the IBYAN was the main mechanism of distribution of new germplasm. With increasing decentralization and expansion into Africa and West Asia, the international trial scheme continues to diversify to meet specific needs of national programs. Nursery design, execution and analyses, and documentation of results as well as seed production and distribution for such trials, will continue to be the responsibilities of this scientist. The IBYAN will continue to be a mechanism to test elite germplasm worldwide. The bulk of germplasm, however, will be distributed through adaptation nurseries (VA), bean program nurseries (VEF), preliminary nurseries (EP) and segregating populations. The VEF-EP-IBYAN scheme will evaluate locally selected lines to integrate the decentralized breeding efforts.The management of this entire scheme is charged to this position.

Soil Microbiology

Past genetic improvement activities for increased nitrogen fixation have led to the development of excellent lines. The relative roles of soil-versus biologically fixed nitrogen are under study and will orient this breeding program. Research on the development of improved screening methodologies for nitrogen fixation, and the selection of efficient strain mixtures will be continued. With the expansion into Africa, the interaction of soil phosphorus and mycorrhiza with the Rhizobium symbiosis will require special attention in order to increase nitrogen fixation in traditional low-input production systems on infertile soils.

Program Leader

The size of the Bean Program and its administrative load requires a full-time leader, and this position became effective in 1985.

Regional Staffing Requirements

The composition of the program at headquarters is seen as the central research and training core to support and strengthen national programs worldwide that are involved in bean research. Through increased decentralization and networking, such a team can fully support a bean research network in which national programs will develop increasing self-sufficiency in research.

The Bean Program's policy of evaluating newly developed germplasm thoroughly, along with similarities in production conditions and constraints within the various bean-growing regions, has ensured that CIAT-derived materials are generally adapted to other production regions. For this reason, the deployment of current headquarters-based research staff to regional programs is not contemplated. Headquarters staff are considered necessary to develop solutions to difficult research problems through the strength of a multidisciplinary team.

Specific regional problems—such as BGMV in Central America and Brazil, the *Apion* pod weevil in Central America, and the bean fly, BCMV, bean scab and halo blight in Africa—will be studied in collaboration with national programs in the regions concerned. Decentralized regional projects are designed to unite and strengthen these national programs.The support of the Title XII Bean/Cowpea Collaborative Research Support Program within US universities and of other institutions in the developing and developed world will further strengthen the bean research network.

The Bean Program projects that four important bean production regions will justify decentralized regional projects in the eighties. The similarity of ecological conditions within each region (and therefore similar production constraints and varietal requirements) and the presence of many small national programs warrant such projects. Such projects seek to locate well-trained CIAT scientists within each of these regions to work within national programs. These scientists have a basic role as training officers who assist national programs to improve and focus their research programs; improve nursery management and the evaluation and use of new materials. They are not there to execute CIAT nurseries in the region per se. Through the division of research responsibilities among participating countries, each national program can concentrate on fewer areas of research, share results with and profit from other national programs participating in such networks. The Central American regional project has shown the viability of such a strategy in a region where national research needs to be strengthened and where regional-specific problems exist.

The four decentralized regional programs that have been identified are Central America and the Caribbean; Brazil and the Southern Cone; Eastern and Southern Africa, and West Asia-North Africa.

Central America and the Caribbean

This region, with numerous small national bean programs often serving similar ecological zones, in countries with high per capita bean consumption, will continue to rely on the CIAT program during this decade. Transfer of germplasm and technology from CIAT and among national programs is carried out by three scientists stationed in the region. The SDC-funded project is composed of a regional coordinator-pathologist, an agronomist and a breeder. In the coming years the project will concentrate on those countries where progress has been lacking because of staff instability and/or difficult varietal requirements. Special emphasis will be placed on the Caribbean. At the end of the current phase of restricted core funding (transferred special project) in 1986, the breeder position will be discontinued. This position is projected for placement in Brazil as the regional liaison scientist for Brazil and the Southern Cone.

Brazil and the Southern Cone

Brazil, with 55 percent of the Latin American bean production, has large national and state programs. Close collaboration between the research programs of Brazil and CIAT has been developed to ensure a two-way technology flow. Collaborative development of technology that will overcome soil aluminum toxicity and low phosphorus availability for 85 important bean production zones in Brazil will continue to be emphasized in this decade.

The one outposted research scientist in Brazil works with Brazilian scientists as part of a national bean research effort and also acts as a liaison scientist with CIAT. At present this position is provided on a temporary basis from headquarters staff. However, the importance of Brazilian bean production and the importance of tolerance to infertile soils warrant the stationing of a staff member in the country. The technology developed on these soils is expected to be relevant for many areas in Africa with similar soil conditions. Expansion of these liaison activities to other Southern Cone countries is projected during the decade with the establishment of a core-funded liaison position in 1987.

Eastern and Southern Africa

Africa, the second largest tropical bean production region, has a much higher per capita legume consumption (over 50 kg per year in some countries) than Latin America. CIAT materials in the IBYAN are frequently well adapted to African conditions, but have been shown to lack tolerance or resistance to specific African production problems. It is expected that major gains can be made with CIAT assistance in bean research despite the distance involved and quarantine restrictions.

CIAT's strategy for Africa has been the subject of three workshops involving representations of national research agencies from bean-growing countries. The first held in Malawi in 1980[40] provided the baseline data and recommendations of national representatives upon which CIAT began to build a regional effort in Sub-Saharan Africa. The second workshop[41], held at CIAT in 1983, was mainly concerned with the design of a regional project for Eastern Africa. The third meeting was a regional research conference of national representatives from the SADCC countries which met at Gaborone, Botswana, in early 1984.[42]

Based on the different ecological zones in which beans are produced in Africa, and the parallel nature of donor support to these zones, CIAT has developed an integrated Sub-Saharan regional strategy, based on three separately funded long-term corelike projects as follows:

Eastern Africa. This project will develop a collaborative research network with Kenya, Uganda, Ethiopia, Somalia and northern Tanzania. Much of the major bean-producing areas in this vast region is concentrated in a few similar ecological zones. This project will be composed of a regional coordinator/pathologist, breeder, cropping systems agronomist and an economist. The first funding commitment through the CDA mechanism is for five years, starting in 1985 and a second five-year funding period is expected.

Great Lakes Region. The regional coordinator/breeder, pathologist, cropping systems specialist, nutritionist (associated staff) and agrono-

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40 **Potential for field beans in Eastern Africa: Proceedings of a Regional Workshop held in Lilongwe, Malawi, March 1980**, CIAT, Cali, Colombia, 1981.

41 **Workshop on integration of research efforts of Bean/Cowpea CRSP, CIAT and national programs in Eastern and Southern Africa,** November 1983, CIAT, Cali, Colombia (mimeo).

42 D. R. Laing, D. J. Allen, A. van Schoonhoven, and J. H. C. Davis, 1985. CIAT's strategy of improvement of bean production systems in Africa, in **Proceedings SADCC Regional Research Conference,** Botswana, 1984. SADCC, Botswana, 1985.

mist (associated staff) of this SDC-funded project serve the Francophone countries of the Great Lakes—Rwanda, Burundi, Zaire (mainly the Kivu region), and with a possible extension into western Tanzania. The initial funding is for three years starting in 1984, but long-term funding is expected.

Southern Africa. An Africa-wide coordinator, breeder, entomologist and a cropping system agronomist are projected to serve the SADCC countries; i.e., Malawi, Zimbabwe, Zambia, Swaziland, Lesotho, Botswana, Angola, Monzambique and Tanzania, with collaborative linkages to Mauritius and Madagascar. Bean flies, which do not occur in Latin America, and aphids are also more important in Africa; thus an entomologist is projected to serve all the three African subregional projects. Prospects for long- term funding for this project are good, and the base location will probably be in Malawi.

The three projects, expected to be largely operational by the end of 1985, will interact and complement each other to form an integrated African regional program. Intercountry cooperation in bean research is critical as a project strategy in each case. Self-sufficiency in research, regional cooperation and increased bean production are the primary aims of these projects.

West Asia and North Africa

In this bean-production area of North Africa and West Asia, beans are important as a warm season legume crop, often produced under irrigation. Turkey, Iran, the Yemen Arabic Republic and Pakistan are among the largest producers. Mediterranean bean-producing countries are expected to contribute new technology to this project, which was developed following the recommendations from a regional bean workshop, jointly organized by CIAT and ICARDA in 1983.[43] The one regional liaison scientist / breeder projected for this project would to be stationed within the legume program (FLIP) of ICARDA, but would be responsible to CIAT for technical matters. This project is projected to begin in the second half of this decade.

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[43] **Potential for Field Beans (*Phaseolus vulgaris* L.) in West Asia and North Africa: Proceedings of a Regional Workshop in Aleppo, Syria, May 1983.** CIAT, Cali, Colombia.

Bilateral Arrangements

The Bean Program will continue to use special bilateral funding to cooperate closely with individual national programs where these projects fit a set of defined criteria for CIAT involvement. At present one such scientist is working in Peru under World Bank funding to INIPA. Other similar projects may develop and are useful in those countries where accelerated progress is necessary to meet urgent national goals. However, the program plans to limit involvement in such activities so that ongoing core responsibilities are not affected.

Collaborative Research with Basic Research Institutions

The Bean Program will continue to seek collaborative basic research projects with research institutions in both the developed and developing world. Such research often involves expertise, equipment etc. that CIAT lacks; or it must be done elsewhere because of quarantine barriers for intercontinental germplasm movement. CIAT, as a more applied research institute, has less comparative advantage in basic research compared to the well-trained and equipped university research potential that exists in many countries. Active projects are under way with the Netherlands (on virus research), England (halo blight, N-fixation, storage insects and specific physiological traits), the USA (angular leaf spot), and Belgium (interspecific hybridization). Additional collaborative research is being sought on temperature adaptation, bean viruses, and bean tissue and anther culture. In the USA, such research is mostly concentrated in universities participating in the Bean Cowpea CRSP-Title XII project. In these collaborative projects, CIAT limits its role to applied issues, while the more basic research institutions carry out the more basic research on special project funds from interested donor agencies.