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PROJECT IP-1

Bean Improvement for Sustainable Productivity, Input Use Efficiency, and Poverty Alleviation

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IP-1: Project Overview[1]

Title: Bean Improvement for Sustainable Productivity, Input Use Efficiency, and Poverty Alleviation

Objective: To increase bean productivity through improved cultivars and natural resource management practices in partnership with NARS and Regional Networks.

Outputs: High-yielding beans with less dependency on pesticides, fertilizers, and water. Beans with stable yield and high nutritional value that combine abiotic and biotic constraints' resistance.

Gains: Improved varieties grown on 40% of the area in Latin America by year 2003. Productivity stabilized and bean availability secured for poor rural and urban consumers in targeted areas. Pesticide use cut by 40% in targeted areas, thus reducing hazards to environment and health. Public and private researchers have access to beans with multiple resistance. Research capacity strengthened through regional networks.

Milestones:

2000 Lines combining resistance to BGMV, common bacterial blight, and BCMV are distributed in Central America, the Caribbean, and the Andean zone; IPM components and systems for whiteflies, pod borers, and leafminers developed and tested. Phosphorus-efficient and aluminum-tolerant genotypes developed.

2001 Parental materials with improved drought tolerance distributed. Strategy developed for stable angular leaf spot resistance. Molecular markers developed for P efficiency.

2002 Commercial-seeded lines combining resistance to BCMV, BCMNV, BSMV, and bean sterility virus will be available. Nutritional quality traits incorporated into cultivars.

2003 Marker-assisted selection developed for various biotic constraints. Lines with resistance to ALS, drought, and BGMV developed. Specialty types developed in Andean beans.

Users: Small-scale farmers in tropical America and Africa will obtain higher and more stable yields. Poor consumers, especially women and children, will benefit from low-cost protein and micronutrients. The environment and community at large will benefit from reduced pesticide and fertilizer use. Food legume researchers will access an enhanced knowledge base and germplasm.

Collaborators: *Regional networks and institutions*: PROFRIJOL and PROFRIZA (Central and Andean America); PABRA (Africa). *International institutions* such as CATIE and EAP-Zamorano (Central America). Universities and other institutions in Australia, Belgium, Canada, France, Spain, Switzerland, and USA. *Resistance breeding and gene tagging*: Bean/Cowpea CRSP.

CGIAR system linkages: Breeding (70%); Crop Production Systems (10%); Protecting the Environment (10%); Networks (5%); Training (5%).

CIAT project linkages: Germplasm conservation (SB-1), germplasm characterization (SB-2). IP-1 contributes to: improved beans for Africa (IP-2), IPM (PE-1), fertilizer efficiency (PE-2), sustainable hillside systems (PE-5), and participatory research (SN-3). Its impact is assessed in BP-1.

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[1] For acronyms and abbreviations used, see page 187.

PROJECT WORK BREAKDOWN STRUCTURE

Project IP- 1: Bean Improvement for Sustainable Productivity, Input Use Efficiency, and Poverty Alleviation

Project Purpose

To increase bean productivity through improved cultivars and natural resource management practices in partnership with NARS and Regional Networks.

OUTPUTS	**Improved small-seeded Middle American bean germplasm with less dependence on inputs.**	**Improved large-seeded Andean bean germplasm with less dependence on inputs.**	**Strategies developed for management of diseases and pests in bean-based cropping systems.**	**Improved cultivars and management practices developed and tested in partnership with IP-2 Project (Africa), NARS, and Regional Networks.**
ACTIVITIES	• Developing germplasm tolerant to abiotic stresses of drought and low soil fertility. • Developing germplasm with multiple resistance to diseases. • Developing germplasm with resistance to pests: *Zabrotes*, *Acanthoscelides*, *Empoasca*, *Apion*, *Thrips palmi*, and bruchids. • Incorporating wider genetic diversity into beans.	• Developing germplasm resistant to diseases. • Developing germplasm resistant to insects. • Incorporating wider genetic diversity into beans.	• Characterizing and monitoring pathogen and insect diversity. • Characterizing disease and insect resistance genes. • Developing IPM components.	• Supporting breeding programs in NARS, Regional Networks, farmers' associations, and CIALs, with germplasm and technical knowledge. • Collaborative projects developed and executed with NARS and Regional Networks. • Supporting NARS and Regional Network researchers on soil and crop management. • Supporting human resource development in NARS and Regional Networks.

LOGICAL FRAMEWORK MATRIX[2]

PROJECT: **Bean Improvement for Sustainable Productivity, Input Use Efficiency, and Poverty Alleviation**
CODE: IP-1
MANAGER: César Cardona
TIME: January 2000- December 2000

Narrative Summary of Outputs	Objectively Verifiable Indicators	Means of Verification	Critical Assumptions
Goal: To obtain a lasting increase in food availability and incomes of the poor through improved bean productivity.	Increased bean production with improved cultivars and natural resource management practices.	National production statistics.	Adoption continues at least at rates comparable to those in the past.
Purpose: To increase bean productivity through improved cultivars and natural resource management practices in partnership with NARS and Regional Networks.	NARS and Regional Networks use improved cultivars and/or management practices on 15% of the area in Latin America by the year 2000.	Reports of NARS and Regional Networks. Publications. CIAT Reports.	Critical mass of bean researchers and operation budgets are maintained. Continued donor support to Regional Networks.
Output: **1. Improved small-seeded Middle American bean germplasm with less dependence on inputs.**	Improved parents/populations/lines available to NARS and Regional Networks.	Report of NARS and Regional Networks. Annual reports and publications.	Continued donor support to PROFRIJOL and CIAT. Continued input of SS breeder.
Activities: 1.1 Developing germplasm tolerant to abiotic stresses of drought and low soil fertility.	• Parents/populations/lines tolerant to drought/ low soil fertility available.	Report of NARS and Regional Networks. Annual reports and publications.	Continued Plant Nutritionist's input.
1.2 Developing germplasm with multiple resistance to diseases.	• Parents/populations/lines resistant to ALS, ANT, CBB, BCMV, BGMV available.	Report of NARS and Regional Networks. Annual reports and publications.	Continued full SS Pathologist input. Continued Virologist input.
1.3 Developing germplasm with resistance to pests: *Zabrotes*, *Acanthoscelides*, *Empoasca*, *Apion*, *Thrips palmi*, and bruchids	• Parents/populations/lines resistant to Mexican bean weevil, leafhopper, and pod weevil are available.	Report of NARS and Regional Networks. Annual reports and publications.	Continued Entomologist's input.
1.4 Incorporating wider genetic diversity into beans.	• QTL analysis completed for at least one population.	Annual reports.	Adequate budget to sustain level of activity.

Continued.

[2] For acronyms and abbreviations used, see page 187.

LOGICAL FRAMEWORK MATRIX – continued.

Narrative Summary of Outputs	Objectively Verifiable Indicators	Means of Verification	Critical Assumptions
Output: **2. Improved large-seeded Andean bean germplasm with less dependence on inputs.**	Improved parents/populations/lines available to NARS and Regional Networks.	Report of NARS and Regional Networks. Annual reports and publications.	Continued donor support to the Andean zone, PROFRIJOL and CIAT. Continued input of SS breeder for the Andean zone.
Activities: 2.1 Developing germplasm resistant to diseases.	• Parents/populations/lines resistant to ALS, ANT, CBB, BCMV, and BGMVare available.	Report of NARS and Regional Networks. Annual reports and publications.	Continued full SS Pathologist input. Continued Virologist input.
2.2 Developing germplasm resistant to insects.	• Parents/populations/lines resistant to Mexican bean weevil and leafhopper are available.	Report of NARS and Regional Networks. Annual reports and publications.	Continued Entomologist input.
2.3 Incorporating wider genetic diversity into beans.	• Find QTL derived from wild beans that can be useful in improving cultivated beans.	Molecular analysis.	Continued input of breeder and Pathologist.
Output: **3. Strategies developed for management of diseases and pests in bean-based cropping systems.**	IPM strategies developed. Gene combinations to control insects and pathogens determined.	Report of NARS and Regional Networks. Annual reports and publications.	Continued input of Pathologist, Entomologist, and Virologist. Continued donor support to whitefly IPM project.
Activities: 3.1 Characterizing and monitoring pathogen and insect diversity.	• Variability of pathogens and insects is known. • Spacial distribution of pathotypes/biotypes defined.	Collection of pathogen isolates and insects available.	Continued active collaboration with partners. Core support to collections.
3.2 Characterizing disease and insect resistance genes.	• Genes resistant to specific races of pathogens and biotypes of insects identified. • Strategy for stable resistance to ALS and anthracnose developed.	Reports and publications.	Continued collaboration with ARO.
3.3 Developing IPM components.	• Individual IPM components are available for whitefly control.	Report of NARS and Regional Networks. Annual reports and publications.	Continued participation of members in systemwide initiative on IPM. Continued donor support to whitefly IPM project.

Continued.

LOGICAL FRAMEWORK MATRIX – continued.

Narrative Summary of Outputs	Objectively Verifiable Indicators	Means of Verification	Critical Assumptions
Output: **4. Improved cultivars and management practices developed and tested in partnership with IP-2 Project (Africa), NARS, and Regional Networks.**	Bean productivity increased. Farmers' dependence on inputs reduced. Production costs reduced.	Trials on experiment stations and on-farm. National statistics. Publications.	Continued donor support. Active collaboration with all partners involved, including farmers.
Activities: 4.1 Supporting breeding programs in NARS, Regional Networks, farmers' associations, and CIALs, with germplasm and technical knowledge.	• Improved germplasm and methodologies are incorporated into national and regional breeding programs.	Reports of NARS and Regional Networks. Publications.	Continued interest by partners to use germplasm. Climatic problems permit advance and selection. Support of database programmer.
4.2 Collaborative projects developed and executed with NARS and Regional Networks.	• Projects submitted to donors	Communication from donors to Project Office. Funds received.	Partners are interested. Donors show interest and are committed.
4.3 Supporting NARS and Regional Network researchers on soil and crop management.	• Improved cultivars are tested under different soil fertility conditions.	Document of Operational Plan. NARS Network reports. Publications.	Donor support for Phase VIII of PROFRIJOL. Active participation of collaborators.
4.4 Supporting human resource development in NARS and Regional Networks.	• CIAT scientists participate as partners in regional events	Documents and reports on events. Joint authorship in publications with NARS partners.	Donor support for human resource development.

Research Highlights in 2000

Output 1: Improved small-seeded Middle American bean germplasm with less dependence on inputs

- Multiple stress resistance to abiotic constraints such as drought, aluminum toxicity, and low nutrient supply was confirmed in several genotypes, especially in G 21212, which presents efficient transport and utilization of photosynthates and nutrients toward grainfilling.

- Two bred lines (SEA 5 and CAP 4) and two landraces (G 21212 and G 1977) were very well adapted to drought stress because of their ability to mobilize photosynthates for grain production. Drought resistance equal to or better than that of SEA 5 was obtained in bred lines with superior plant type and acceptable grain color.

- Modest levels of drought resistance were recovered from interspecific crosses with *Phaseolus acutifolius*.

- Lines and landraces tolerant to toxic level of aluminum in soil and tolerant to low nutrient supply were identified.

- Two bred lines and one Mexican landrace were tolerant to waterlogging.

- The selection of the *bgm-1* gene was applied to about 9000 individual plants and the backcross program to improve commercial varieties with intermediate resistance to bean golden yellow mosaic virus (BGYMV) is nearing completion.

- Sources of resistance to bean golden mosaic virus (BGMV), bean common mosaic virus (BCMV), bean severe mosaic virus (BSMV), and cowpea chlorotic mottle virus (CCMV) were identified in parental materials, and in intermediate and advanced common bean breeding lines.

- Resistance to angular leaf spot (ALS) was identified in a number of *P. vulgaris*, *P. polyanthus*, and *P. coccineus* genotypes.

- Potential sources of ALS resistance were identified in interspecific crosses between *P. vulgaris* and *P. polyanthus* or *P. coccineus*.

- 25 bean genotypes with high levels of resistance to *Phaeoisariopsis griseola* races from Africa, Central America, and South America were identified.

- 10 bean genotypes with high levels of resistance to *Macrophomina phaseolina* were identified.

- Breeding for resistance to *Ascochyta* blight has been successful in creating families with superior resistance that will serve to improve both major gene pools and snap bean types.

- New sources of resistance to *Thrips palmi*, *Empoasca kraemeri*, *Zabrotes subfasciatus*, and *Acanthoscelides obtectus* were identified.

- The methodology to screen for resistance to thrips was refined.

- New lines possessing disease and insect resistance were selected.

- Incorporation of resistance to leafhopper in Andean bean types was reinitiated.

Output 2: Improved large-seeded Andean bean germplasm with less dependence on inputs

- Genetic improvement efforts to incorporate BCMV resistance in highland common bean cultivars are under way.

- Six genotypes with high levels of resistance to race 651 and 653 were identified.

- Red-mottled beans for the Andean and Caribbean regions were improved for disease resistance by pyramiding sources of resistance to ALS and by using marker-assisted selection to incorporate BGMV-resistance genes. *Empoasca* and bruchid resistances were combined into lines containing virus resistance.

- Cream-mottled beans were improved for yield and quality by crossing with Colombian Cargamanto beans and incorporating BCMV-resistance and bush type architecture.

- A new nursery of Andean genotypes (IBN 2000) was tested for ALS and common bacterial blight (CBB) resistance and distributed to collaborators.

- Higher yielding lines with commercial seed type were obtained from advanced backcross populations derived from crosses between cultivated Andean and wild common beans.

- Triple-cross Andean populations were developed to introgress traits from Mesoamerican climbing beans.

- The inheritance of low-phosphorous tolerance was studied in an Andean population.

- Andean climbing beans of heat-tolerant commercial type were developed and tested.

Output 3: Strategies developed for management of diseases and pests in bean-based cropping systems

- 55 *Phaeoisariopsis griseola* and *Colletotrichum lindemuthianum* isolates were chracterized using host differential interactions.

- 400 isolates of *Xanthomonas campestris* pv. *phaseoli* (XCP) and *X. campestris* pv. *phaseoli* var. *fuscans* (XCPF) have been characterized using repetitive extragenic palindromic polymerase chain reaction (REP-PCR) and DNA restriction fragment length polymorphisms (RFLP) of the 26S ribosomal genes. Results show that XCP is very distinct from XCPF.

- 125 *C. lindemuthianum* isolates were characterized using microsatellites and REP-PCR.

- Polymorphic random amplified microsatellites (RAMS) fragments were cloned to develop locus specific markers.

- 400 *P. griseola* isolates were characterized using RAMS and all isolates were put into Andean and Mesoamerican groups.

- The "Afro-Andean" group is part of the Andean group that represents isolates resulting from point mutations in genes for virulence.

- The presence of BGYMV virus in Colombia was confirmed.

- 150 recombinant inbred lines (RILs) were identified as having high levels of common bacterial blight (CBB) resistance under both field and greenhouse conditions.

- 16 lines were identified that combine Andean and Mesoamerican angular leaf stem (ALS)-resistance genes.

- Inheritance of ALS resistance to Andean and Mesoamerican *P. griseola* races in G 19833 and DOR 364 is different and complex being recessive for one race and dominant for another, depending on the source of resistance.

- Resistance to *Ascochyta* blight was found to be largely under additive gene control in *P. coccineus* although it tended to be recessive in *P. polyanthus*. From two to four genes appeared to control resistance.

- Quantitative trait locus (QTL) mapping of resistance to *Thrips palmi* shows few genes controlling resistance to insect damage and reproductive adaptation under high infestation pressure.

- QTL mapping of ALS and anthracnose disease resistance shows clustering of resistance genes in the bean genome.

- Populations were developed to study the inheritance of ALS resistance.
- Developed reliable sampling methods for *Thrips palmi* on beans and snap beans.
- Established an action threshold for *T. palmi* on snap beans.
- Identified levels of resistance to insecticides in whitefly (*Trialeurodes vaporariorum*) and thrips populations.
- Developed components and successfully tested management strategies for combined populations of whiteflies and thrips affecting snap beans.

Output 4: Improved cultivars and management practices developed and tested in partnership with IP-2 Project (Africa), NARS, and Regional Networks

- Evaluation of red-mottled, and red- and cream-speckled bean genotypes by farmer-led research committees (CIALs) in Colombia has identified broadly adapted bush bean varieties for mid-elevation ecosystems.
- Characterization of on-farm diversity of local common bean varieties in Nicaragua showed greater than expected genetic variability, which will be correlated with agro-morphological variability in the upcoming season.
- The International *Phaseolus* Information System (IPHIS) database was published for the first time with bean pedigrees, and remaining pedigrees are now incorporated into the IPHIS format.
- A project on breeding for aluminum resistance in bean was approved.
- Continuous support was given to breeding programs in the Proyecto Regional de Frijol para Centro América, México y el Caribe (PROFRIJOL), the Andean zone and African networks.
- Seed was distributed to all collaborating partners.
- CIAT scientists participated in the planning of activities of PROFRIJOL, the Andean zone, and Africa networks.
- Individual training of national scientists was provided.
- Joint collaboration and concept notes were prepared.
- Partners are evaluating a set of 49 genotypes for their adaptation to abiotic constraints such as drought, aluminum toxicity, and low nutrient supply.

- Partners are evaluating a set of 19 genotypes for their response to ALS.

- CIAT bean project scientists actively participated in international conferences and meetings that they attended.

- Individual and group training of national and international scientists was provided.

- A marker database was constructed for an RAPD survey of Andean common bean germplasm.

- Colombian research and extension agents identified regional bean production problems.

- The Web Page for IP-1 in English and Spanish was updated and expanded (http://www.ciat.cgiar.org/projects/ip-1/bar_ip1.htm).