# Crop and Agroecosystem Health Management

## Executive Summary

**Annual Report 2006**
**Project PE-1**

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Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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Crop and Agroecosystem Health Management (Project PE-1)

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# Table of Contents

# 1. Project Description and Logframe

**Project PE-1: Crop and agroecosystem health management**

**Research for Development Challenge: Improving Management of Agroecosystems in the Tropics (IMAT),** CIAT. The project also contributes to the "Enhancing and Sharing the Benefits of Agrobiodiversity Biodiversity."

**Project Manager: Segenet Kelemu**

**Project Description:**

**Goal:** To enhance crop yields and quality of products, reduce pesticide use and residue, and improve agro-ecosystem health through enhancement of soil health and integrated management of major pests and diseases in the tropics.

**Objective:** Develop and transfer pest-and-disease knowledge and management systems for sustainable productivity and healthier agro-ecosystems in the tropics.

**Target Ecoregion:** Humid and sub-humid tropics in eastern and southern Africa, Central America and Andes.

## 1.1. Narrative Project Description

### 1.1.1. Rationale:

Most cultivated plant species are susceptible to a wide range of fungal, bacterial, and viral pathogens, and arthropod pests, particularly in tropical climates. These problems are compounded by the lack of resources and technical assistance to poor farmers in developing countries. Under these conditions, crop losses can often be significant or even total, affecting the livelihoods and food security of millions of poor rural and urban communities. In view of this situation, we could expect that the application of improved and intensive crop protection measures would contribute to the sustainability and enhancement of food production in these regions of the world. The development and application of integrated pest and disease management (IPDM) strategies is the basis of the Crop and Agroecosystem Health Management Project activities. Some of these methods include the development of resistant cultivars, including transgenic plants, and a variety of control measures developed for specific plant diseases/pests and agroecosystems. Biotechnology and/or conventional tools perform essential roles in our research activities dealing with crop and agroecosystem health management.

The Project's research activities are organized around four major outputs: 1) Pest and disease complexes described and analyzed, 2) Pest-and-disease management components and IPM strategies developed, 3) NARS' capacity to design and execute IPM research and implementation, and applications of molecular tools for pathogen and pest detection, diagnosis, diversity studies as well as novel disease and pest management strategies strengthened, 4) Global IPM networks (Integrated Whitefly Management Technology) and knowledge systems developed.

**Output 1: Pest and disease complexes described and analyzed.**

The difficulty of accurately identifying pathogens and pests of tropical crops is often a bottleneck to their control. We, together with various collaborators, have developed several molecular and conventional

diagnostic tools to detect, identify, and characterize pathogens and other pests affecting its mandated crops, that is, beans, cassava, tropical forages, and rice, as well as several high value crops currently grown by small-scale farmers in the tropics.

Extensively characterized pathogen populations at CIAT, with substantial practical implications for their management, include *Xanthomonas axonopodis* pv. *manihotis*, *Colletotrichum gloeosporioides*, *Phaeoisariopsis griseola*, *Pyricularia grisea*, *Sphaceloma manihoticola*, *Colletotrichum lindemuthianum*, species of *Pythium*, *Xanthomonas campestris* pv. g*raminis*, Rice *hoja blanca* virus (RHBV), and begomoviruses and potyviruses that infect important crops found in the tropics. Pests that are well-characterized include species of mealybugs, species of spittlebugs, whiteflies and their parasitoids, biotypes of the whitefly *Bemisia tabaci*, bruchids, and white grubs.

**Output 2: Pest-and-disease management components and IPM strategies developed.**

***Resistance (conventional breeding):*** Managing diseases and pests through host resistance is economically attractive and practical. To develop cultivars resistant to diseases and insect pests, a common strategy, known as 'gene pyramiding', is to incorporate as many resistance genes into a single plant genotype as possible, in the hope that it will be statistically unlikely for a pathogenic race or insect pest to evolve that can overcome all the resistance genes simultaneously. However, combining several resistance genes simultaneously in one background becomes difficult without using markers for each gene. In this context, the use of marker-assisted selection to contain pest damage becomes essential.

***Transgenic crops as components of IPDM strategies:*** Genomic approaches are increasing our understanding of the genetic basis of plant disease and pest resistance by enabling us to better understand resistance genes themselves, other genes, and the pathways they regulate. While fully recognizing the controversy on transgenic organisms, we value the potential role they can play in arthropod pest, disease, and virus management strategies across several crops. The role of transgenic organisms in IPDM will increase in the future and has already been shown as a way of drastically decreasing pesticide use.

Transgenic crops developed at CIAT include *Stylosanthes guianensis* containing a rice-basic chitinase gene for resistance to the fungal pathogen *Rhizoctonia solani*; rice, for resistance to Rice *hoja blanca* virus (RHBV), containing the RHBV nucleocapsid protein (*N*) gene. As the possibilities of combining genes from various sources expand, the need for biosafety regulations and risk assessment increases. Our studies on the effect of transgenic (Bt) varieties on non-target soil organisms showed that no statistical differences were detected in abundance and diversity of soil organisms in conventional versus genetically modified cotton [Bollgard ® Bt Cry 1A ©] during the 2003-05 period in the Cauca Valley, Colombia.

**Bio-pesticides:**

The concerns on excessive pesticide use and the threat to human health and the environment, coupled with increasing regulatory and market pressures, along with pest and pathogen resistance to synthetic chemicals, have led to a reappraisal of approaches to pest and disease control strategies that include the development of safer "biological pesticides." This excessive use of pesticides threatens to weaken the competitiveness of many Latin American countries' agriculture by: 1) threatening to disqualify export products especially in those countries that have stringent food safety regulations, 2) increasing production cost, 3) degrading the general ecosystem, making their soils less productive over time, 4) contaminating water supplies, 5) causing health problems among agricultural workers and thus affecting the labor force. In this context, we believe

natural plant and microbial compounds will play a major role in pest and disease control in both developed and developing countries.

Biological control is an important component of integrated pest and pathogen management. Endophytic microbes, fungi, bacteria, nematodes, viruses, plant-derived compounds are all identified and characterized for use as biocontrol agents against a wide range of pathogens and pests attacking various crops. Biopesticides developed and currently made commercially available in collaborative projects with the private sector include: 1) Biocanii, based on a strain of the fungus *Verticillium lecanii* for the control of whiteflies and thrips on flowers, beans, avocado, cotton, onion, citrus, asparagus, papaya, tomatoes and other horticultural crops; 2) Biorhizium**,** based on two strains of the fungus *Metarhizium anisopliae* for the control of various insects such as spittlebugs in pastures; 3) Biovirus**,** based on a baculovirus and used for the control of cassava hornworm, 4) Ecoswing®,.a biofungicide formulated from extracts of the plant swinglia (*Swinglia glutinosa*).

***Plant-derived compounds:*** We have identified plant-derived compounds that are effective in controlling diseases and pests. These include: 1) fique (*Furcraea cabuya*), 2) swinglia (*Swinglia glutinosa*), 3) *Clitoria ternatea*.

Legumes have been used as cover crops and as sources of green manure. The use of cover crops (e.g. *Canavalaia ensiformis, Crotalaria rahamiana, Crotalaria juncea, C. ochroleuca, Desmodium intortum, D. unicanatum, Lablab purpureus, Tagetes patula, Mucuna pruriens*) has been associated with a decrease in incidence of soil-borne pathogens and pests in several cropping systems.

**Output 3: NARS' capacity to design and execute IPM research and implementation, and applications of molecular tools for pathogen and pest detection, diagnosis, diversity studies as well as novel disease and pest management strategies strengthened.**

The purpose of this output is to strengthen our national partners' capacity to diagnose and detect pests and diseases; develop and execute IPDM strategies that would contribute to the reduction of losses caused by pests and diseases through effective targeting, dissemination and adoption of integrated pest management strategies that are acceptable to smallholder farmers in eastern, central and southern Africa and Latin America. Useful practical experiences have been gained, successes achieved and lessons learnt during the promotion of technologies at target sites. We will help to develop plant diagnostic networks to combat invasive pests, promote regional collaboration, and strengthen local diagnostic and outreach capabilities.

Through strong partnerships with national programs, universities, farmer groups, and the private sector we develop and evaluate diagnostic tools, disease and pest management methods including resistant materials, cultural methods and biopesticides. Capacity building and training of students, farmers and professionals at various levels is a major activity of the project staff.

**Output 4: Global IPM networks (Integrated Whitefly Management Technology) and knowledge systems developed.**

One of our main research areas is the management of whiteflies as pests and vectors of plant viruses attacking a broad range of crops throughout the tropics. Whiteflies are phloem feeders that cause direct damage in some of their hosts by removing large quantities of sap. In addition, species of whiteflies, such as *Bemisia tabaci* and *Trialeurodes vaporariorum*, are vectors of plant viruses of significant economic importance. These whitefly species cause significant and often total direct or indirect (as vectors) damage to a wide range of food and industrial crops throughout the tropics. For example, African cassava mosaic disease is caused by different but related viruses transmitted by *B. tabaci*. Similarly, *Bemisia*-transmitted

viruses affect many traditional (e.g. common bean) and non-traditional (e.g. tomato, peppers, cucurbits) crops in the tropics. The pest problem that is associated with many horticultural crops is often dealt with multiple applications of pesticides. These and other similar scenarios have major consequences to food security, human and agroecosystem health, and farm income.

In the1990s, new inter-center initiatives including the System-wide Program on Integrated Pest Management (SP-IPM) were created by the CGIAR. Due to the importance of whiteflies and the viruses they transmit, the Tropical Whitefly IPM Project (TWFP) was the first inter-center project within SP-IPM. The Project was developed in three phases to be carried out over a 10-year period, and launched in 1997 with CIAT as the convening Center. Five IARCs (CIAT, IITA, AVRDC, ICIPE, CIP), 12 advanced research institutes, and 31National Agricultural Research and Extension Systems in Latin America, Caribbean, Africa and Asia are included. This extensive partnership was made possible through the financial support of six major donors: Danish International Development Agency (DANIDA), Australian Center for International Agricultural Research (ACIAR), United States Agency for International Development (USAID), Ministry of Foreign Affairs and Trade (MFAT, now New Zealand Aid), U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS), Department for International Development (DFID, UK)

### 1.1.2. CGIAR System Priorities:

The Crop and Agroecosystem Health Management Project contributes essentially to all the 5 CGIAR Research Priorities (2005-2015). Specific activities conducted by the Project to contribute to the CGIAR priorities are:

- Developing molecular and conventional methods for screening of germplasm for resistance to diseases and pests- (Priority 1)
- Characterization of germplasm and identification of sources of resistance to diseases and pests- (Priority 1)
- Developing phytosanitory methods and protocols for the safe movement of germplasm-(Priority 1)
- Identification, characterization and conservation of beneficial microorganisms associated with plant germplasm (eg. endophytic bacteria and fungi), and predators of harmful pets-(Priority 1)
- Enhancing yields of crops through pest and disease resistance- (Priority 2)
- Reduction of pesticide use in various crops including high value crops, thus reduction of pesticide residue and improving food safety- (Priority 2)
- Monitoring pathogens and pests that develop resistance to pesticides- (Priority 2)
- Screening high value crops for resistance to key pathogens and pests- (Priority 3)
- Management of diseases and pests in fruits and vegetables- (Priority 3)
- Developing methods to prevent post harvest losses- (Priority 3)
- Improving water quality through pesticide use reduction- (Priority 4)
- Enhancing soil health through improved and integrated disease and pest management strategies- (Priority 4)
- Development and implementation of integrated disease and pest management strategies for sustainable management of agroecosystems- (Priority 5)
- Development of phytosanitary protocols and certification systems to facilitate international trades- (Priority 5)

### 1.1.3. Impact Pathways:

The project contributes to improved crop productivity and improved livelihoods through development of efficient and accurate tools for disease and pest diagnosis (output 1), and cost-effective

disease and arthropod pest management strategies (output 2). We screen for host plant resistance and identify important sources of resistance to a wide range of pests and pathogens. These sources of resistance are used in the breeding programs to incorporate the resistance genes with a number of other genes of agronomic importance. We develop other components of integrated pest and disease management strategies including biopesticides and cultural practices. The capacity of our national partners to diagnose and detect pathogens and pests and to implement effective disease and pest management strategies is enhanced through our activities in output 3. We communicate our results through publications in international and regional journals, books and manuals, articles presented in conferences and workshops, websites, and in English, Spanish and other major local languages. Other communication outlets are newspaper articles and other journals intended for the general public. Global networks on sustainable management of key pests, such as whiteflies, which attack staple crops, high value crops and industrial crops are established (output 4). The outputs of the Project benefit NARS scientists, farmers, and consumers by increasing crop yields, crop quality, agro-ecosystem health and stabilizing production systems. The judicious use of pesticides results in clean harvests with little or no pesticide residues, leading to increased income and market access through healthier products, and cleaner environment.

**1.1.4. International Public Goods:**

The project works on diseases and pests of rice, beans, cassava, tropical forages and tropical fruits. In addition to the research activities involving CIAT's commodity crops, the Project scientists are also involved in projects that expand their expertise to other agricultural and industrial crops. These include maize, cotton, onions, asparagus, other vegetables, potatoes, cut flowers and oil palm.

The Project has played a major role in the formation and development of the CGIAR Systemwide Program in IPM (SP-IPM). CIAT is the Convening Center for the major ongoing project in the SP-IPM, The Tropical Whitefly IPM Project. A draft SP-IPM proposal on "Soil Biota, Fertility and Plant Health" is available. The Project staff as well as the TSBF Institute of CIAT have played major roles in this proposal.

The Instituto Agronómico de Colombia (ICA) invited the Project and its scientists to apply for, and acquire accreditation to evaluate the quality and effectiveness of biological pesticides. The CIAT laboratories and scientists would become registered with ICA to perform quality control analysis of biopesticide products of commercial producers seeking ICA registration. Furthermore, the Project is invited to participate in major activities of ICA involving phytosanitary issues. The citrus virus certification work that the Project has conducted in collaboration with ICA and CORPOICA is now considered as a model for expansion to other crops, diseases and regions.

The science dealing with the identification, naming and classification of organisms, is a vital component in a pest management program. An inaccurate identification of a pest organism can result in an acute loss of time and resources and delay the most appropriate response to pest attack. The Project provides a service for the identification of arthropod pests and pathogens collected from various crops, but especially from CIAT's mandated crops, and related activities. The Project maintains a working collection, now totaling over 20,000 specimens, of arthropod pests and their natural enemies for cassava, beans, rice, tropical pastures and tropical fruits, as well as those collected from related agroecosystems. A database containing information on individual specimens accompanies this collection and this is made available to collaborating institutions, museums, universities and national research and extension programs. The project also maintains large collections of fungal and bacterial pathogens, and beneficial microorganisms including nitrogen fixers, plant growth promoters, biocontrol agents. In addition, a collection of entomopathogenic fungi, bacteria and nematodes is also maintained. These potential biological control agents have been isolated from crop pests through field surveys, or have been received from other research institutions (e.g. CENICAFE) in collaborative exchange projects.

The project uniquely works on endophytic fungi and bacteria, multiple resistances to spittlebugs, microbial and plant-derived biopesticides. Several biopesticides have been commercially made available through collaborative projects with the private sector. The project staff in Africa provide capacity building in molecular tools for disease diagnosis and pathogen characterization, marker assisted selection methods to improve the efficiency of breeding for disease resistance, participatory evaluation and implementation of disease and pest management methods, as well as supervision of graduate student thesis.

The research outputs of the PE-1 Project are in line with the mandate of the CGIAR of producing international public goods (IPGs). The IPGs of the research outputs of this Project are summarized as follows:

1. Mechanisms:
   a) Understanding mechanisms of resistance to fungal, bacterial and viral pathogens leading to the development of screening methods
   b) Understanding mechanisms of resistance to arthropod pests thus, leading to development of methods for resistance screening.
   c) Understanding mechanisms of how pathogens and pests evolve and overcome host resistance
   d) Understanding mechanisms of hoe pathogens and pests evolve and develop resistance to pesticides

2. Methods:
   a) Techniques and methodologies for mass rearing of arthropod pests for resistance screening and biopesticide testing
   b) Standardized protocols for risk evaluations of genetically modified organisms (GMOs) on non-target soil organisms.
   c) Genetic transformation methods for pathogenic and non-pathogenic fungi and bacteria.
   d) Methods for long-term storage of microbes.
   e) Methods for artificial inoculation/infestation and for resistance measurement for a number of pathogens and pests.
   f) An improved greenhouse inoculation method to detect quantitative differences for genetic studies and breeding, and evaluation, eg. sheath blight resistance (*Rhizoctonia solani*) in rice
   g) Methods for screening potential biopesticides
   h) Protocols for the safe movement of germplasm within and across regions

3. Products:
   a) Genotypes with resistance to pests and diseases identified among the collection of beans, cassava, rice, tropical forages and tropical fruits
   b) High yielding disease and pest resistant breeding lines
   c) Microbial-derived biopesticides
   d) Plant-derived biopesticides
   e) Improved biocontrol agents
   f) Microbial and arthropod pest databases.

**1.1. 5. Partners:**

- **Bolivia**- PROIMPA: Management of whitefly.
- **Brazil**- EMBRAPA- CNPMF, - CNPGC, IAC – Development of host plant resistance to spittlebugs
- **Canada**- Agriculture & Agri-Food- *Pythium* species identification
- **China**- Yunnan Academy of Agricultural Sciences – Development of runner bean project

- **Colombia-** CORPOICA, ICA, Universidad Nacional de Colombia-Palmira and Bogotá, Life Systems Technology (LST) S.A, Universidad del Valle, Universidad de Caldas, Universidad Católica, Universidad de la Amazonía, Universidad de los Andes, Profrutales Ltda, BIOTROPICAL, Palmar del Oriente: provide samples, validation of control and management practices); Corporación BIOTEC, FEDEPLATANO: farmers groups, and many more; graduate and undergraduate thesis of students, development of disease and pest diagnosis tools, evaluation of pest and disease management methods, quarantine pests and diseases, certification programs; - Biotropical: development, evaluation and formulation of biopesticides.
- **Denmark -** The Royal Veterinanry and Agricultural University: induced resistance and training
- **Ecuador-** Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Escuela Politécnica del Ejército (ESPE): pest and pathogen resistance to pesticides, research on soil arthropods. Manrecur: management of whitefly.
- **France**- IRD: insect physiology and biochemistry.
- **Germany-** Institut für Pflanzenkrankheiten und Pflanzenschutz, Fachbereich Gartenbau, Universität Hannover, Agrar- undErnährungswissenschaftliche Fakultät, Universität Kiel, Federal Biological Research Centre for Agriculture and Forestry (BBA): soil arthropod pests, entomopathogens.
- **Honduras**- PROMIPPAC: biopesticides
- **Kenya**- International Centre of Insect Physiology and Ecology (ICIPE): insect physiology.
- **Nicaragua**- MAGFOR: capacity strengthening in disease and pest diagnosis, disease and pest management.
- **Nigeria**-IITA: System –wide program on IPM, management of whiteflies.
- **Peru**-CIP: management of whiteflies.
- **Rwanda**- Institut des Sciences Agronomiques du Rwanda (ISAR): integrated disease and management and soil fertility management for enhancing soil health
- **Taiwán**- AVRDC: management of whiteflies in tropical crops.
- **Tanzania**- Agricultural Research Institute, African Highlands Ecoregional Program, Adventist Development and Relief Agency, Ministry of Agric.-Armyworm project, Farm Africa, Farm Africa, World Vision, farmers groups, and others: Evaluation of disease and pest management methods.
- **Uganda**- National Agricultural Research Organization (NARO), African Highlands Ecoregional Program, Makerere University, Uganda National Agricultural Advisory services, farmers groups, and others: Evaluation of disease and pest management methods, thesis students.
- **United Kingdom**- Commonwealth Agricultural Bureaux International (CABI), Horticulture Research International (HRI), Natural Resources Institute: management of whiteflies. Scottish Crop Research Institute: Isolation and conservation techniques.
- **United States**-University of Kentucky, Cornell University, Iowa State University, Kansas State University, University of Georgia, University of Florida, University of California-Davis, Michigan State University, Texas A& M, United States Department of Agriculture (USDA): insect taxonomy, analysis of alkaloids from endophytes, diagnosis and detection tools.
- **Venezuela**- Instituto Nacional de Investigación Agrícola (INIA): pesticide use and resistance of pathogens and pests to agrochemicals.

### 1.2. Project Log-frame (2006-2008)

**Project: Crop and Agroecosystem Health Management**

**Project Manager: Segenet Kelemu**

| | Outputs | Intended User | Outcome | Impact |
|---|---|---|---|---|
| **Output 1** | Pest and pathogen complexes in key crops described and analyzed. | NARIs, universities, NGOs, IARCs | • Molecular and conventional tools for disease and pest diagnosis, detection and characterization developed, evaluated and disseminated to researchers. | • Improved crop productivity from more efficient and accurate tools for disease and pest diagnosis, and cost-effective disease and insect pest management strategies.<br>• Improved livelihoods of small farmers through higher yields of crops obtained by better disease and insect pest management |
| **Output 1 Targets 2006** | Invasive pest species, white grub, burrower bugs and their natural enemies taxonomically identified and characterized | NARIs, universities, NGOs, IARCs | • Pest characterization tools developed and adopted by researchers. | |
| **Output 1 Targets 2007** | Molecular tools for detection, diagnosis and diversity studies of key pathogens and pests of CIAT commodities made available | NARIs researchers in LAC, Asia and Africa, IARCs | • Disease and pest characterization tools developed and adopted by researchers. | |
| **Output 1 Targets 2008** | Two plant- growth promoting bacteria and one biological control agent characterized. | NARIs researchers in LAC, Asia and Africa | • New options for disease and pest management and plant health enhancement developed and tested by researchers. | |
| **Output 2** | Pest-and-disease management components and strategies developed for key crops. | Researchers in LAC, Asia and Africa | • Integrated disease and pest management strategies developed and adopted by farmers. | • Increased and stable income of small farmers through increased crop yields and enhanced quality of products |
| **Output 2 Targets 2006** | Bean, cassava, rice and tropical forage lines resistant to major diseases and pests and molecular markers associated with some of these resistance genes identified | Researchers in LAC, Asia and Africa | • Tools that contribute to efficient breeding strategies developed | |

PE-1 project Log Frame (Continued)

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|---|---|---|---|---|
| **Output 2 Targets 2007** | At least 2 *Brachiaria* genotypes with spittlebug resistance, a whitefly resistant cassava variety, and 50 blast and sheath blight resistant rice lines developed. | Researchers in LAC, Asia and Africa; CIAT scientists; farmers | • Selected genotypes of *Brachiaria*, cassava and rice tested for resistance to insects and pathogens in different regions. | |
| **Output 2 Targets 2008** | Three biological pesticides, and angular leaf spot and *Pythium* resistant bean varieties made available | Researchers in LAC, Asia and Africa; farmers | • Disease /pest resistant crops developed and adopted; biopesticides formulated and adopted. | |
| **Output 3** | Strengthened capacity of NARS to design and execute IPM R&D, to apply molecular tools for pathogen and pest detection, diagnosis, diversity studies and to device novel disease and pest management strategies | NARIs in LAC, Asia and Africa; farmers | • Improved capacity of NARS partners to disseminate to farmers disease and pest management strategies | • More income to farmers by using; environmentally-friendly disease and pest management strategies. |
| **Output 3 Targets 2006** | Use biopesticides and other pest management practices on common bean crop transferred to farmers in Malawi, Kenya, Tanzania and Uganda | NARIs in Africa; farmers | • Improved disease and pest management strategies adopted | |
| **Output 3 Targets 2007** | Management strategies for soil-borne pests (white grubs and burrowers bugs) evaluated with farmers | NARIs and farmers in LAC, Africa | • Soil pest management methods adopted by farmers. | |
| **Output 3 Targets 2008** | Combination of whitefly resistant cassava varieties and biological control agents made available to farmers | NARIs, NGOs and farmers | • Improved cassava varieties together with improved disease and pest management practices adopted. | |

PE-1 project Log Frame (Continued)

| | | | | |
|---|---|---|---|---|
| **Output 4** | Global IPM networks (Integrated Whitefly Management Technology) and knowledge systems developed. | NARIs, Universities, NGOs, IARCs, farmers | • Sustainable food and cash crop production systems with reduced environmental impact and production costs adopted. | • Improved livelihoods, rural and urban health standards, and increased farm/household income |
| **Output4 Targets 2006** | Guidelines and technical information on whitefly management distributed in Asia, Africa and Latin America | NARIs, Universities, NGOs, IARCs, farmers | • Information on improved whitefly management strategies disseminated | |
| **Output 4 Targets 2007** | Farmer participatory research conducted in selected pilot sites of sub-Saharan Africa, S.E. Asia and Latin America. | NARIs, Universities, NGOs, IARCs, farmers | • Methods in lower pesticide use resulting in lower production costs and environmental contamination adopted. | |
| **Output 4 Targets 2008** | Impact assessment and Policy guidelines implemented for the benefit of farmers. | Government Institutions, NARs, NGOs, farmers | • Food production and income-generating strategies for small-scale farmers facilitated by official decrees | |

## 1.3. CGIAR Output template 2006

**PE-1**
**Crop and Agroecosystem Health Management**

| | Output Targets 2006 | Proof of Achievements |
|---|---|---|
| **OUPUT 1**<br>Pest and pathogen complexes in key crops described and analyzed. | Invasive pest species, white grub, burrower bugs and their natural enemies taxonomically identified and characterized | Achieved. Annual Reports 2005, 2006, other publications (see publication list) |
| **OUTPUT 2**<br>Pest-and-disease management components and strategies developed for key crops. | Bean, cassava, rice and tropical forage lines resistant to major diseases and pests and molecular markers associated with some of these resistance genes identified | 90% achieved. Annual Reports 2005,2006, other publications (see publication list) |
| **OUTPUT 3**<br>Strengthened capacity of NARS to design and execute IPM R&D, to apply molecular tools for pathogen and pest detection, diagnosis, diversity studies and to device novel disease and pest management strategies | Use biopesticides and other pest management practices on common bean crop transferred to farmers in Malawi, Kenya ,Tanzania and Uganda | 75% achieved: Annual Reports 2005, other communiques |
| **OUTPUT 4**<br>Global IPM networks (Integrated Whitefly Management Technology) and knowledge systems developed. | Guidelines and technical information on whitefly management distributed in Asia, Africa and Latin America | Achieved<br><br>A book and technical manuals in English and Spanish developed; other publications (see publication list) |

## 2. Research Highlights

### *2.1. Project Operations*

The project has been reviewed in 2006 by a Center Commissioned External Review (CCER) panel and it was rated as one of the best managed and most successful projects at CIAT in terms of achieving output targets and impacts, quality of science and other performance indicators. The CCER panel that reviewed the PE-1 Project noted the following in its report:

1) "…More broadly, our analysis indicates that projects with a high proportion of external grant funding (e.g., PE-1 and PE-2, >80% of total funding) have the following features:

   - Graduate more students per FTE senior staff.
   - Meet international standards for refereed journal publications per FTE senior staff.
   - Build strong collaboration with other academic institutions of national and international standing.
   - Significant proportion of related research that builds on prior efforts, i.e., a clear succession of research with a recognizable comparative advantage, a long-term strategy and long-term collaboration.
   - Good "marketing" and standing in the global scientific community, which makes the project attractive to scientists and donors.
   - Strong leaders that guide and facilitate with emphasis on high scientific standards, interaction, and professional development of researchers." *[page 12, CCER Report 2006]*;

*2)* "…PE-1 outputs on parasite and pathogen population genetics have supported the work of breeders in developing germplasm with durable resistance; the work on endophytes has improved the tolerance of *Brachiaria* to drought as well as to parasites and pathogens; finally, the evaluation and release of biopesticides have contributed to lessening contamination with chemical pesticides*."[page 17, CCER Report 2006]*;

3) "…The projects are operating with varying degrees of interaction with each other and with other CIAT projects, ranging from a high degree of autonomy and isolation (PE-3, and some work in BP-2) to opportunistic and periodic collaboration to selective inclusion of personnel from other units (PE-2), to highly integrated collaborative arrangements (PE-1). The latter in some cases include formal cross-allocation of personnel, shared proposal development, project planning, and research management, as well as joint publication (PE-1 and to some extent PE-2 and BP-2). " *[page 19, CCER Report 2006]*;

*4)* "Consistently high (84-90% of total) external grant funding per FTE senior scientific staff, averaging about $370,000/FTE. In absolute terms, lowest core funds allocation per senior scientific staff (about $54,000/FTE) of all IMAT projects." *[page 22, CCER Report 2006]*;

*5)* "Largest number of graduate students completed per senior staff FTE." *[page 22, CCER Report 2006]*;

6) "Various other products (website, tech manuals, commercialized biopesticides, etc.) *[page 22 , CCER Report 2006]*;

*7)* "Crop and Agroecosystem Health Management project scientists have strategically upgraded their goals and objectives from a prior focus on immediate increments in crop yields and reductions in pesticide contamination to more crucial and longer-term commitments. These include: [1] understanding the interactions between plants and their parasites and pathogens (PP), whereupon [2] ecologically sound management tactics are developed and [3] shared with partners, leading finally [4] to global networks. This approach is implemented throughout the research activities of a project staff that is partly shared with the agrobiodiversity RDC . The immediate beneficiaries of this strategy are farmers, rural populations, consumers and the living components of the ecosystem. With this adjustment, Crop and Agroecosystem Health Management harmonizes with the expressed views of the Center. " *[page 22, CCER Report 2006]*;

8) "….As these associations reflect the adequacy of thorough cooperation within CIAT, the launching of the CG System-Wide Project on Whitefly is an exemplary case of extensive collaboration of Crop and Agroecosystem Health Management across institutions and countries." [*pages 22, 23, CCER Report 2006]*;

9) "Through its four tactical outputs, Crop and Agroecosystem Health Management shows an impressive list of scientific as well as down-to-earth achievements. The quantity and value of its incursions into molecular approaches for PP diagnostic and population genetics analysis are remarkable, as is the applicability of the knowledge generated by these investigations to crop improvement and management." *[page 23, CCER Report 2006]*;

10) "Crop and Agroecosystem Health Management has a strong esprit de corps that derives from the long association between much of the international and national senior and support staff. This bond fosters a commitment to ensure good laboratory and field practices. Nonetheless, the financial difficulties of the Center combined with personnel management procedures and policies have weakened the stability and economic and academic incentives for the national support staff. In the long run this may reduce their numbers below a critical threshold and impinge upon their morale." *[page 23, CCER Report 2006]*;

11) "…The strategy of Crop and Agroecosystem Health Management for producing these public goods ----tangible biopesticides as well as intangible diagnosis protocols, keys to identify natural enemies of PP or other kinds of knowledge --- has profited from having a capable staff and leadership and well equipped facilities." *[page 24, CCER Report 2006]*

**2*.2. Significant Achievements-2006***

A summary of achievements in 2006 listed below is organized around four major research activities of the project:

## 1. Pest and pathogen detection, diagnosis and genetic diversity

- Several interspecific lines, combining resistance to angular leaf spot, anthracnose, ascochyta blight and *Rhizoctonia* root rots were identified in beans. These materials constitute an important set for use in breeding programs intended for multiple constraint improvement.

- Research results revealed that the *Colletotrichum lindemuthianum* pathogen population structure in Colombia has changed, with the disappearance of some previously prevalent pathotypes. However, the population remains exclusively of the Andean lineage.

- The molecular SCAR marker designated as $PF9_{260}$ linked to the common bean angular leaf spot resistance genes in G10474 and G10909 functions effectively in both Andean and Mesoamerican backgrounds.

- Molecular markers that are linked to P*ythium* root rot resistance in resistant bean varieties RWR 719, MLB 49-89A, and AND1062 were identified, and protocols for two SCAR markers, PYAA19 and PYB08, were developed. These markers are currently being used in markerassisted selection for root rots in Kampala, Uganda.

- The usefulness of combining near-isogenic progeny analysis with rice genome information available in public databases to identify molecular markers highly linked to blast resistance genes in rice was demonstrated. Although a limited number of polymorphic markers can be expected when near-isogenic lines are used as progenitors, six polymorphic markers in a region of only 13 cM surrounding the blast resistance gene *Pi-1(t)* were identified. Additionally, two of these markers (RM1233*I and RM224) were closely linked to the gene. The results support the utility of these DNA markers in marker assisted selection and gene pyramiding rice breeding programs addressing the improvement of blast resistance in rice cultivars; and eventually to map based cloning of the gene. The speed, simplicity and reliability of PCR based approaches make microsatellite analysis on agarose gels an attractive tool for marker-assisted selection in rice breeding programs aiming at developing durable rice blast resistant cultivars.

- The internal transcribed spacer (ITS) regions of the ribosomal DNA of *Colletotrichum* isolates infecting citrus, tree tomato and mango were analyzed using the polymerase chain reaction (PCR) method. Furthermore, the degree of genetic diversity of 91 isolates of *Colletotrichum* spp from citrus and tree tomato was measured at molecular level by random amplified polymorphic DNA (RAPD) with thirteen arbitrary primers of ten bases, and by amplified fragment length polymorphism (AFLP). Both RAPD and AFLP products revealed very limited polymorphism among the 91 isolates examined. Amplifications with the primers CaInt2 – ITS4, indicated that all the isolates tested, with the exception of 4 isolates and the control isolate *C. gloeosporioides* (Cg), amplified a product with a 490 bp size that indicates that the species is *Colletotrichum acutatum*.

- Tests indicated that anthracnose of stems of Andean blackberry is caused mainly by *Colletotrichum acutatum*. However, even though it is the major causal agent, it also appears to be part of a complex of *Colletotrichum* species attacking Andean blackberry.

- Multiplex PCR were used to classify strains of *Ralstonia solanacearum* and confirmed that their current classification is composed of four genetic groups or phylotypes and, within these, subgroups or sequevars that corresponded to clusters or isolates with similar pathogenicity or isolates of common geographic origin. To date (with about 40% of the collection at CIAT evaluated), 100% of strains isolated from Musas in Colombia belong to phylotype II, with 91% to sequevar 4 and 6.6% to sequevar 6.

## 2. Pest-and-disease management components and IPM strategies developed

- Levels of resistance to important insect pests confirmed in bean

progenies. Resistance to the bean weevil (*Acanthoscelides obtectus*) was identified in *Phaseolus vulgaris* x *P. acutifolius* hybrids. Progress was also obtained in yields by selecting tolerant bean lines for the *Empoasca kraemeri*.

- Successful screening for sources of resistance to the new virus disease affecting snap bean was conducted. This is caused by the bean-leaf crumple virus, a Begomovirus, transmitted by *Bemisia tabaci* biotype B.

- Research data strongly suggest that endophytic bacteria have a direct beneficial effect on plant growth and development, and possibly on associated nitrogen fixation in *Brachiaria*. In nitrogen- and other nutrient-deficient conditions, *Brachiaria* plants inoculated with the three endophytic bacterial strains had significantly higher average values in all evaluated parameters, plant height, number of tillers, number of leaves, and leaf area than the control plants.

- Characterization and comparison of partial sequence of *nif*H gene in strains of endophytic bacteria associated with *Brachiaria* genotypes showed that the three sequences from the endophytic bacteria isolated from *Brachiaria* CIAT 36062, designated 01-36062-R2; 02-36062-H4, and 03-36062-V2, are closely related to *Klebsiella, Enterobacter* and *Micrococcus*. Microorganisms in these three genera are known to be nitrogen-fixers. *Nif* genes that encode the nitrogenase complex and other enzymes involved in nitrogen fixation have consensus sequences identical in various nitrogen-fixing bacteria.

- Two-hundred nine *Brachiaria* genotypes (127 with BR05 series and 82 with RZ 05 series) were planted and screened for *Rhizoctonia* foliar blight disease in the field at Macagual ICA/CORPOICA Research Station in Florencia, Caquetá. The resistant control CIAT 16320 was consistently evaluated at scale less than 2 on a scale of 0-5. Ten genotypes, RZ05/3635, BR05/0262, RZ05/2721, RZ05/3551, RZ05/3634, RZ05/3738, RZ05/2738, RZ05/2919, RZ05/3394, and RZ05/3575 were evaluated at an average between 2.0 and 2.5.

- Endophytic bacteria that reside in plant tissues without causing any visible harm to the plant have been isolated from surface-sterilized *Brachiaria* tissues. The introduction of these bacteria had a positive effect on plant growth and development in the recipient plants CIAT 36061 (cv. Mulato) and CIAT 6294 (cv. Marandu). More tiller and root development were observed in artificially inoculated plants than control plants containing only indigenous endophytic bacteria or no endophytic bacteria.

- Cassava root rots were successfully reduced under field conditions Eastern Plains region and in Cauca**,** Colombia by using *Trichoderma viride* and *Trichoderma harzianum* as biocontrol agents.

- Lixiviates from decomposing plantain rachises, pseudostems, and fruit are ideal ecological resources for use in managing the disease *moko* or bacterial wilt. These lixiviates contain various nutrients and minerals, in particular, high levels of potassium and manganese, and bacteria which help reduce the disease.

## 3. NARS' capacity to design and execute IPM research and implementation, and applications of molecular tools for pathogen and pest detection, diagnosis, diversity studies as well as novel disease and pest management strategies strengthened

- Whiteflies have become the target of excessive pesticide use by snap bean and dry bean farmers in the Andean zone. A management system for whiteflies that contribute to reduce pesticide use has been developed and tested with farmers in Colombia and Ecuador (see 2002-2004 Annual Reports). In 2006 we continued and expanded diffusion of technology activities at both sites in Colombia, Ecuador and Bolivia.

- Seventeen graduate and fifteen undergraduate students have conducted their thesis work under the supervision of the project staff in 2006.

- More than 723 professionals have participated in capacity building courses and seminars organized by the project staff and partners.

- Project staff participated in a number of regional and international conferences throughout 2006.

- Six visiting scientists have spent time working in various research activities.

- Many farmers groups have participated in disease and pest management capacity building activities.

- More than 50 high level visitors, and more than 250 graduate, undergraduate, high school and elementary school students have visited the various research activities of the project.

- Assistance in disease and pest diagnosis, development of molecular tools for rapid detection of pathogens provided to NARS.

- Three major awards were received by members of the Project in 2006.

- Fourteen refereed journal articles, one non-refereed journal article, 7 books and book chapters, 20 conference/workshop papers and posters, 4 technical manuals, bulletins and other publications. Furthermore, 4 articles have been written on some of our interesting research results in newspapers and other outlets.

## 4. Global IPM networks (Integrated Whitefly Management Technology) and knowledge systems developed.

- Dissemination of validated integrated pest management technology in developing countries affected by whitefly pests and whitefly-transmitted viruses that hinder food production and socio-economic development in the tropics continued in 2006.

- In Asia and particularly India, the deployment of improved tomato lines possessing resistance to whitefly-borne viruses has been very successful. These lines are being constantly improved for other agronomic traits in order to increase their market value and levels of adoption of these varieties by small-scale farmers.

- Resistance to whiteflies as pests has also been identified and transferred to commercial cassava cultivars in South America. Crosses with African cassava cultivars have already been made in hopes of transferring the resistance identified in South America, to African cultivars affected by different whitefly species in sub-Saharan Africa.

- Cassava whitefly diagnostic survey was carried out with the assistance of the National Coffee Federation in each department, and CORPOICA and ICA (Regional Quindio) in Colombia. Surveys with cassava farmers were done between 1100 and 2900 m.a.s.l.
  Numerous cassava pests were recorded during these surveys: Whiteflies were the most important and predominant, and recorded on 76% of the farms surveyed.

## 3. Outcome: **Dissemination of validated integrated pest management technology in developing countries affected by whitefly pests and whitefly-transmitted viruses.**

Phase III of the Tropical Whitefly Integrated Pest Management Project (TWFP) emphasizes the transfer of integrated pest management (IPM) information and improved germplasm to small-scale farmers affected by whitefly pests and viruses transmitted by whiteflies in the tropics. The lack of improved germplasm possessing pest and disease resistance, and insufficient technical assistance to small-scale farmers, have been identified as the main constraints hindering the management of whitefly and whitefly-borne viruses that affect food production of major staples, such as cassava and common bean, and the adoption of high value crops, such as tomato, peppers and cucurbits, by small-scale farmers seeking to maximize the income derived from their limited landholdings. Therefore, it is necessary to disseminate information and train agronomists and agricultural technicians on the most effective IPM practices available to control these pests.

The sub-Saharan Africa sub-project continues to train farmers and disseminate information and resistant cassava and sweet potato varieties in their target areas, primarily in Tanzania, Uganda and Nigeria. Emphasis on the education of farmers and adoption of phytosanitation practices is also important in this sub-project, as many farmers do not understand basic concepts of virus/vector epidemiology, such as the use of virus-infected vs. virus-free planting material; the role of infected plants as virus sources in the field; virus symptomatology; and the role of whiteflies as pests and virus vectors. This knowledge is critical to promote the adoption of virus-resistant cassava and sweet potato varieties in this region.

In Central America, the distribution of common bean varieties possessing resistance to whitefly-borne viruses continues at a fast pace, together with the dissemination of information on the rational use of selective insecticides. The TWFP is helping the national agricultural research program of El Salvador to multiply seed of these improved varieties for distribution to small-scale farmers, together with an IPM package designed to reduce pesticide inputs.

In the Andean region, the farmer field schools and complementary farmer participatory approaches have been very successful in increasing common bean yields and reducing pesticide applications in pilot sites of Colombia and Ecuador. This experience is being replicated in Bolivia, where farmers are currently struggling with whitefly pests in their meso-thermic valleys where traditional food crops have been diversified with high value horticultural crops to increase farm income. In these regions, we can find mixed cropping systems that include basic crops, such as maize, beans and potatoes, and high-value crops, such as tomato and peppers. In these environments, whiteflies act mainly as direct pests and, consequently, the project has been promoting the implementation of ‘economic or action thresholds’ that tell farmers when to apply in order to minimize production costs and maximize yields.

# 4. Performance Indicators: Publications

| | |
|---|---|
| Journal Articles in Refereed Journals (Published, In press) | 14 |
| Non-refereed journal article | 1 |
| Books and Book Chapters | 7 |
| Conference and Workshop papers | 20 |
| Technical manuals and Bulletins | 4 |
| Newspaper and Internet articles | 5 |

**Refereed journal articles**


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**Non-refereed Journals**

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Calvert, L. A., Lentini, Z. 2007. Rice hoja blanca virus. In: "Characterization, Diagnosis & Management of Plant Viruses Vol. 4" Eds. Rao, G.P., Bragard, C. and Lebas, B.S.M. (In press) pp. 85-98.

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Holguin, C. M., Herrera, C. J., Bellotti, A. C. 2006. Diagnóstico de Moscas Blancas (*Homoptera: Aleyrodidade*) en Yuca *Manihot Esculenta* de la zona cafetera de Colombia. [Poster]. Resúmenes XXXIII Congreso Sociedad Colombiana de Entomología, SOCOLEN. Julio 26-28, Manizales, Colombia. p.125.

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Kelemu, S., Abello, J., Garcia, C. 2006. Agrobacterium-mediated transformation of *Acremonium implicatum* with green fluorescent protein (GFP) gene. (abstract). Phytopathology 96:S59.

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Moorhead, A. 2006. Finotin, a promising new biopesticide. New Agriculturist, UK. [on line] [ cited January 2006] available in : http://www.new-agri.co.uk/06-/focuson/focuson3.ht

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Voice of America two hour interview with Segenet Kelemu – Amharic program –October 2006.

# 5. Performance Indicators: Resource Mobilization

## 5.1. List of new and ongoing special projects in 2006

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | CIAT (lead scientist) | Participating Institution (lead scientist) | |
| Precision agriculture and construction of models for tropical fruit crops (2005 – 2007) | COLCIENCIAS Agencia Colombiana de Cooperación Internacional (ACCI) MADR Colombia | Corporación BIOTEC | (Elizabeth Alvarez) | 406,248 (Myriam Sánchez) | 425,564.00 |
| Dynamics of sources of inoculum and analysis of the anthracnose pathogen population infecting tropical fruits (2005 – 2007) | COLCIENCIAS, Colombia | CORPOICA | (Segenet Kelemu) 46,459 | (Jairo Osorio) | 219,046.00 |
| Evaluation of cross protection as a strategy for the control of tristeza virus in citrus (2005 – 2007) | COLCIENCIAS, Colombia | CORPOICA | (Lee Calvert) | (Jorge Gómez) | 35,500.00 |
| Development and implementation of phytosanitary certification program for citrus. (2006 – 2008) | Ministry of Agriculture and Rural Development (MADR), Colombia | CORPOICA, ICA, Profrutales Ltda. | (Lee Calvert) | Corpoica; ICA (Jorge Gómez, Jorge E. Angel) | 118,820 (approved) 261,114.00 (total project cost) |

**5.1.** List of new and ongoing special projects in 2006 (continued)

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | **CIAT** (lead scientist) | **Participating Institution** (lead scientist) | |
| Utilization of resistant varieties for the control of cassava frogskin disease in the Atlantic coast and Cauca zones (2005-2008) | Ministry of Agriculture and Rural Development (MADR)-IICA | Corporación para Estudios Interdisciplinarios y Accesoria Técnica (CETEC), Asociación Nacional de Productores y Procesadores de Yuca (ANPPY) | 7,241 (Lee Calvert) | 11,340 [Roger de Jesús Ramos (ANPPY), Alberto Rodríguez (CETEC)] | 53,000.00 |
| Increasing Cassava Productivity through Integrated Pest Management (2005 – 2007) | Inter-American Institute for Cooperation on Agriculture (IICA), Colombia | Live Systems Technology (LST), S.A., Bogotá , Colombia | 42,213 (Andreas Gaigl) | (Esperanza Morales) | 83, 246.00 |
| Lulo with aggregated value: New alternatives for the small holder (2006 – 2008). | Ministry of Agriculture and Rural Development (MADR), Colombia | CORPOICA La Selva, Universidad de Antioquia | 148,689 (all two years) (Alonso Gonzalez, Zaida Lentini, Elizabeth Alvarez) | 53,433 (Mario Lobo) | 202,122 |

**5.1.** List of new and ongoing special projects in 2006 (continued)

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | **CIAT** (lead scientist) | **Participating Institution** (lead scientist) | |
| Pest and Disease Resistance, Drought Tolerance and Increased Shelf Life Genes from Wild Relatives of Cassava and the Development of Low-cost Technologies to Pyramid them into Elite Progenitors (2005 – 2007) | The Generation Challenge Programme, CGIAR | EMBRAPA-CNPMF, Brazil<br>Namulonge Agricultural and Animal Production Research Institute (NAARI)<br>Crop Research Institute (CRI)<br>National Root Crop Research Institute (NRCRI) | (Elizabeth Alvarez, Anthony Bellotti, Hernan Ceballos, Martin Fregene) | (Alfredo Alves, Anton Bua, Titus Alicia, Elizabeth Okai, Chiedozie Egesi) | 894,906.00 |
| Integrated disease management in cassava. (2005 – 2007) | Ministerio de Agricultura y Desarrollo Rural de Colombia (MADR) and Inter-American Institute for Cooperation on Agriculture (IICA), Colombia | Live Systems Technology (LST) S.A., Colombia | 41,935 (Elizabeth Alvarez) | (Esperanza Morales, Jaime Jaramillo) | 89,180.00 |

**5.1.** List of new and ongoing special projects in 2006 (continued)

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | **CIAT** (lead scientist) | **Participating Institution** (lead scientist) | |
| Evaluation of the Effectiveness of Biorationals Used in the Management of Bruchid Pests on Beans (Phaseolus vulgaris) by Small-Scale Farmers in the Lake Victoria Basin (2004 – 2007) | SIDA SAREC, Sweden | NARS Universities and research programs in Kenya and Tanzania | (Eliaineny Minja) | (Mabel Imbuga, Paul Tarus, Absolom Munyasi, John Ogecha, Phanice Namungu, Hashim Barongo, Goodluck Kimaro) | 30,000.00 |
| Integrated management of whiteflies in the tropics – Phase III (2005 – 2008) | Department for International Development (DFID), UK | IITA<br>AVRDC<br>CIP<br>CABI<br>NRI | 301,557 (Francisco Morales, Cesar Cardona, Anthony Bellotti, Glenn Hyman) | 449,076 (James Legg, Peter Hanson, Isabel Carballal) | 2,613,071.00 |
| Improvement of nutrient management for the control of mildew disease in roses, caused by the fungal pathogen *Peronospora sparsa* (2006 – 2007) | COLCIENCIAS, Colombia | CENIFLORES<br>ASOCOLFLORES | 19,011 (Elizabeth Alvarez) 60,702 (total) | 7,387 (Rebeca Lee) | 75,969.00 |

**5.1.** List of new and ongoing special projects in 2006 (continued)

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | **CIAT** (lead scientist) | **Participating Institution** (lead scientist) | |
| Promotion of Integrated Pest Management Strategies for Major Insect Pests of *Phaseolus* Beans in Hillsides Systems in Eastern and Southern Africa (2005 – 2006) | DFID, United Kingdom | NARS in Uganda, Kenya, Tanzania and Malawi | (Eliaineny Minja, Robin Buruchara, Kwasi Ampofo) | (Michael Ugen, Fina Opio, John Ogecha, Felister Makini, Catherine Madata, David Kabungo, Patrick Mviha, B. Chibambo) | 113,118.00 |
| Pesticide use reduction and development of resistance to pesticides in rice and beans in Colombia, Venezuela and Ecuador (2005 – 2008) | FONTAGRO | INIA, Venezuela FEDEARROZ, Colombia INIAP, Ecuador | 41,000 (Fernando Correa, César Cardona) | 34,000 (Reinaldo Cardona, Miguel Diago, Sandra Garcés) | 224,000.00 |
| Studies in epidemiology and control of the anthracnose disease of mango (2006-2008) | COLCIENCIAS | CORPOICA | (Segenet Kelemu) 35,000 payment still pending | (Jairo Osorio) | 70,250.00 |

**5.1.** List of new and ongoing special projects in 2006 (continued)

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | **CIAT** (lead scientist) | **Participating Institution** (lead scientist) | |
| Combating the Hidden Hunger in Latin America: Biofortified crops with improved vitamin A, essential minerals and quality project (2005 - 2010) | CIDA | MADR, Universidad de Caldas Petrotesting FIDAR | (Elizabeth Alvarez) (Joe Tohme, Anthony Bellotti, Bernardo Ospina) | Jairo Castaño Jaime Jaramillo José Restrepo | |
| Collection, characterization, and clonal multiplication of avocado with emphasis on identification of lines tolerant to *Phytophthora* spp. (2006-2008) | Ministry of Agriculture and Rural Development (MADR), Colombia | CORPOICA, PROFRUTALES | (Elizabeth Alvarez) (Alvaro Mejia, Alonso Gonzalez, Joe Tohme) | (Juan Jaramillo, Danilo Rios) | 194,705.00 |
| Understanding the Mechanism of Plant Resistance to Whiteflies (2004 – 2008) | United States Department of Agriculture (USDA) | USDA | (Anthony Bellotti) | (Stephen Lapointe) | 61,146.00 (103,146 total budget) |

**5.1.** List of new and ongoing special projects in 2006 (continued)

| Project Title | Donor | Participating Institutions | Amount available in 2006 US$ | | Total project budget US$ |
|---|---|---|---|---|---|
| | | | **CIAT** (lead scientist) | **Participating Institution** (lead scientist) | |
| Implementación de modernas tecnicas de diagnostico molecular de virus, viroides y fitoplasmas en frutales y hortalizas de costa, sierra y selva del Perú (2006-2008) | Centro Internacional de la Papa - CIAT | | (Lee Calvert) (Elizabeth Alvarez) | | 20,000 |

**5.2. List of project proposals and concept notes developed with partners in 2006.**

| Donor/Title | Lead Researcher/ Principal Contact | Total Budget US$ |
|---|---|---|
| **FONTAGRO** Bioplaguicidas como alternativas verdes de control de plagas y enfermedades para aumentar la competitividad de pequeños agricultores Andinos. | S. Kelemu/ C.Cardona/ G. Mahuku | 490,000 |
| **FONTAGRO** Caracterización y manejo de la antracnosis (*Colletotricum spp*) del mango, aguacate y guanábana en Colombia, Ecuador y Perú. | F. Correa | 298,000 |
| **FONTAGRO** Fortalecimiento de cadenas de valor de plátano: innovaciones tecnológicas para reducir agroquímicos. (Approved sept 2006) | E. Alvarez | 250,000 |
| **FONTAGRO** Productores de lulo y mora competitivos mediante selección participativa de clones élite, manejo integrado del cultivo y fortalecimiento de cadenas de valor. (Approved Sept 2006) | A.Gonzalez/ E. Alvarez/ A. Gaigl/ Z.Lentini/M. Gottret | 486,000 |
| **Rural Sector Support Programme – World Bank funded Bilateral programme –** Empowering farmers and strengthening research through capacity building to improve banana productivity in Rwanda: Linking scientist training with farmer participatory research | R. Kirkby/ Clifford S. Gold, Visitng Scientist | 299,610 |
| **CIP -** Implementación de modernas tecnicas de diagnostico molecular de virus, viroides y fitoplasmas en frutales y hortalizas de costa, sierra y selva del Perú. (Approved) | L.Calvert/ | 20,000 |
| **SENA –BPA -** Producir plátano con estándares internacionales de calidad, en fresco y procesadoa través de la implementación de buenas practicas agrícolas BPA, en cinco municipios del departamento del Quindío. | E. Alvarez/John Loke | 89,376 |

**5.2.** List of project proposals (continued)

| Donor/Title | Lead Researcher/ Principal Contact | Total Budget US$ |
|---|---|---|
| **Fondo Nacional Hortifruticula – ASOHFRUCOL** Producir plátano con estándares internacionales de calidad, en fresco y procesado a través de la implementación de buenas practicas agrícolas BPA, en seis (6) municipios del departamento del Quindío. | Elizabeth Alvarez/ John Loke/German Llano | 89,955 |
| **Grupo Agroindustrial La Fabril –** Identificación del agente causal y el manejo de una enfermedad destructiva de Palma de Aceite en Ecuador | John Loke | 95,865 |
| **Fondo latinoamericano de innovación en palma africana (FLIPA) –** identificación del agente causal y el manejo de una enfermedad destructiva de palma africana en Colombia y Ecuador | Elizabeth Alvarez /John Loke | 603,456 |
| **MADR -** Fortalecimiento de la cadena productiva de mora, mediante manejo integrado de enfermedades y selección de clones élite. | E.Alvarez | 337,952 |
| **MADR** Ajuste y validación de innovaciones tecnológicas para reducir agroquímicos en plátano | E. Alvarez | 260,870 |
| **Sub-Saharan Africa Challenge Program -** Increasing the productivity, stability, sustainability and profitability of smallholder agriculture in vulnerable production systems through more effcient use of water and nutrients. (Approved) | G. Mahuku | 1,000,000 |
| **SPII, Karaj, Iran -** Improvement of Chitti bean in Iran. (Approved) | G. Mahuku | 224,000 |
| **Rockefeller Foundation -** Enhancing Crop Productivity: Exploiting the molecular basis of host-pathogen interaction to develop durable disease resistance in African crops, using Angular Leaf Spot disease of bean as a model | G. Mahuku | 322,230 |
| **FONTAGRO -** Habichuelas (vainitas) *verdaderamente* verdes: Una alternativa limpia para generar empleo e ingreso para pequeños agricultores. | G. Mahuku | 490,000 |
| **Sub-Saharan Africa Challenge Program -** Improving potato-bean-sweetpotato (PBS) based rural livelihood systems through integrated soil ecosystem management (ISEM), market development and nutritional innovation in the highlands of Lake Kivu area. | G. Mahuku | 2,000,000 |
| **Federal Ministry of Finance (BMF), Austria -** Improving fruit and vegetable product quality from smallholder systems: Optimizing soil-crop-pest management for economically viable, socially acceptable and ecologically sustainable production | G. Mahuku | 921,700 |
| **Bilateral project for Belgium -** Improving rural livelihoods in Rwanda: Promoting integrated crop, disease, and pest management (ICDPM) strategies for intensification and diversification of agricultural systems | G. Mahuku | 3,900,000 |

## 6. Performance Indicators: Capacity building

### 6.1. List of training courses, workshops & seminars offered in 2006

| Event | Date | Organizer/ Place | Participants | Received by |
|---|---|---|---|---|
| Field Day –Biology and management of *Trialeurodes vaporariorum* in beans and snap beans | May 5 | CIAT-Bean entomology / Pradera, Colombia | 76 | Farmers and technicians South Valle |
| Field Day –Biology and management of *Trialeurodes vaporariorum* in beans and snap beans | March 22 | CIAT-Bean entomology /Tenerife (Cerrito, Valle) | 54 | Farmers and technicians –South Valle |
| Field Day –Biology and management of *Trialeurodes vaporariorum* in beans and snap beans | July 22 | CIAT-Bean entomology /Tenerife (Cerrito, Valle) | 92 | Farmers in South Valle and North Cauca |
| Pest identification techniques | Oct | CIAT- cassava Entomology – | 1 | Chiclayo SENASA Peru. |
| Foro Internacional sobre innovación y alianzas para el desarrollo del cultivo de plátano | Dec 6 | CIAT- Palmira Agronatura- Cassava pathology | 32 | Professors, students, technicians, farmers |
| Curso sistemas modernos de producción procesamiento y utilización de la yuca | | CIAT- MAGFOR | 4 | MAGFOR staff offcials Ricardo Valerio, Marlin Torres Picado, Fanor Guerrero Nuñez, Manuel Davila Villegas. |
| Sampling insects, biology of whiteflies | March 17 | CIAT – Bean Entomology | 15 | Students Universidad del Valle Cali, Colombia |
| Management of Whiteflies | June 16 | CIAT – Bean Entomology | 100 | Farmers in Cáqueza and Fómeque (Cundinamarca) |

**6.1.** List of training courses, workshops & seminars offered (continued)

| Event | Date | Organizer/ Place | Participants | Received by |
|---|---|---|---|---|
| Management of whiteflies | July 28 | CIAT – Bean Entomology | 50 | Professionals, professors, students, technicians and farmers in XXXII Congress SOCOLEN Manizales |
| Management of pest in beans | Aug 27 | CIAT – Bean Entomology | 43 | Farmers associated to FENALCE in Tolima |
| Management of whiteflies | Aug 28 | CIAT – Bean Entomology | 53 | Flower's technicians in Antioquia |
| Whiteflies identification | Sept 6 | CIAT – Bean Entomology | 2 | Tito Anzoategui, Angel Fernando Copa Universidad Autonoma Gabriel Rene Moreno - Bolivia |
| Management of pest in beans | Nov 15 | CIAT – Bean Entomology | 31 | Professors, and students Nariño University |
| Management of pest in beans | Nov 27 | CIAT – Bean Entomology | 5 | CGIAR Directing Board |
| Management of whiteflies | Nov 20 | CIAT – Bean Entomology | 101 | Students, technicians and farmers in Seminar Potato good management practices in East Antioquia. |
| Management of pest in beans | | CIAT – Bean Entomology | 1 | Patricio Gallegos INIAP, Ecuadaor |
| Management of whiteflies | March | CIAT –Palmira cassava pathology | 1 | Elias Espindola Distraves - Barrancabermeja |

**6.1.** List of training courses, workshops & seminars offered (continued)

| Event | Date | Organizer/ Place | Participants | Received by |
|---|---|---|---|---|
| Reconocimiento y manejo de enfermedades de yuca | April | CIAT –Palmira cassava pathology | 1 | Antonio Uset, Instituto Nacional de Tecnología agropecuaria (INTA) Argentina |
| Capacitacion en diagnostico de enfermedades y evaluacion de resistencia enfermedades en yuca | July-Oct | CIAT – Palmira cassava pathology | 1 | Godwin Ameorphe Internacional Atomic Energy Agency, IAEA Ghana |
| Field Day: Manejo de Moko en palatino | June 23 | CIAT – Palmira cassava pathology | 50 | Farmers and technicians Finca Santa Elena, Armenia |
| Field Day: Manejo de Moko en platano | Ago 31 | CIAT – Palmira cassava pathology | 15 | Farmers and technicians finca La Yalta, Armenia |
| Field Day: Manejo de moko en platano | Dec 15 | CIAT – Palmira cassava pathology | | Farmers and Technicians, Tulúa. |

## 6.2. List of students supervised in 2006

**Ph D. Thesis**

| Name | Supervisor | University | Title |
|---|---|---|---|
| **Claire Mukankusi** (Sep 2003 – Aug 2007) | Robin Buruchara | University of Kwazulu-Natal, South Africa | Breeding beans (*phaseolus vulgaris* L.) for resistance to Fusarium root rot (*Fusarium solani* f. sp. *Phaseoli*) and large seed size in Uganda |
| **Virginia Gichuru** (Sept 2005 – Aug. 2006) | Robin Buruchara | Makerere University, Uganda | Symptomatology and characterization of *Phythium* spp. of major crops in a bean based cropping system in sout-western Uganda |
| **Lucia Afanador Kafuri** (July 2006 – July 2009) | Elizabeth Alvarez | Universidad Nacional Medellin - Colombia | Anthracnosis of Castilla's blackberry – variability in the species, races of the casual agent and identification of resistance sources. |

| | | | |
|---|---|---|---|
| **MSc Thesis** | | | |
| **Juan Fernando Mejia** (Oct. 2005 – Oct. 2007) | Elizabeth Alvarez | Universidad Nacional, Palmira - Colombia | Identification of resistance gene analogs associated with superelongation disease of cassava. |
| **Alberto Rojas MSc** (Feb 2006- April 2007) | Elizabeth Alvarez | Universidad de Caldas - Colombia | Identification of anthracnose management strategies in guanábano (*Annona muricata*) with emphasis in resistance and biofungicide use in the departments of Valle del Cauca and Huila |
| **Jose Moderafa Magia** (Jan 2005 – Jan 2007) | Fernando Correa | Universidad Nacional, Palmira - Colombia | Inheritance of resistance to *Pyricularia grisea* in different rice cultivars |
| **Francisco Lopez Machado** (Aug.2005 - Dec 2006) | Cesar Cardona | Universidad del Valle, Cali-Colombia | Characterization of tolerance to damage caused by the adults of *Aeneolamia varia* (F.) as a component of resistance in the genotypes of *Brachiaria* spp. |

**6.2.** List of students supervised in 2006 (continued)
**MSc Thesis**

| Name | Supervisor | University | Title |
|---|---|---|---|
| **Maria Elena Cuellar Jimenez** (Feb 2004 - March 2006) | Francisco Morales | Universidad del Valle, Cali - Colombia | Bean leaf crumple virus: Transmisión by whiteflies (Gennadius) (Homoptera: Aleyrodidae), search for sources of resistance in *Phaselous vulgaris* L. and epidemiology. |
| **Natalia Villareal** (March 2006-June 2007) | Lee Calvert<br>Juan Antonio Garcia | Centro Nacional de Biotecnología Madrid, Spain | Protein expression of the Cassava Frog skin virus (FSV) in bacterial systems (E. coli) |
| **Ulises Castro** | Cesar Cardona | Universidad de Chapingo, Mexico | Mechanisms of resistance to *Aeneolamia Albofasciata* and *Prosapia simulans* in *Brachiaria* spp. |
| **Natalia Labrin** (June 2005 – Jan 2007) | Lee Calvert | CATIE, Costa Rica | Ecological Agriculture in the area of genetics to resistance in Venezuelan rice varieties (*Orytza Sativa*) to the white leaf virus |
| **Alejandro Pabon** (Jul 2004 – March 2006) | Cesar Cardona | Universidad de Viçosa, Brazil | Mechanisms of resistance to *Deois incompleta*, *D. Schah* and *Notozulia entreriana* in *Brachiaria* spp. |
| **Paola Sotelo** (Jan 2005 – Dec 2006) | Cesar Cardona | Universidad Nacional, Palmira - Colombia | Inheritance study of a new begomovirus in snap beans (*Phaseolus vulgaris*) in the Cauca Valley |
| **Ana Karine Martinez** (Junio 2005 – Junio 2007) | Francisco Morales | Universidad Nacional, Palmira – Colombia | Characterization of *begomovirus* and evaluation of tomato lines for resistance to *begomovirus* in the Cauca Valley |
| **Maritza Cuervo** (Jan 2005 – Sept 2006) | Lee Calvert | Universidad Nacional, Palmira – Colombia | Molecular characterization of isolates of the virus associated with cassava frogskin disease collected from production zones in Colombia |

**6.2.** List of students supervised in 2006 (continued)

**MSc Thesis**

| Name | Supervisor | University | Title |
|---|---|---|---|
| **Adriana Maria Sanabria Moreno** (Dec 2006 – Dec 2007) | Segenet Kelemu | Universidad Nacional , Bogota – Colombia | Genetic diversity among isolates of the anthracnose pathogen infecting tropical fruits |
| **Linda Jeimmy Rincon Rivera** | George Mahuku | Universidad Nacional, Bogota - Colombia | Virulence and Molecular characterization of *Colletotrichum lindemuthianum* isolates from different bean production zones of Colombia |

**BSc Thesis**

| Name | Supervisor | University | Title |
|---|---|---|---|
| **Luz Adriana Meza Becerra** (Feb 2005 – Dec. 2006) | Elizabeth Alvarez | Universidad del Valle, Cali - Colombia | Microbiological, chemical and Physical evaluation of sources of lixiviate residues of plantain and its effects in the management of bacterial wilt (Finca La Florida) |
| **Eliana del Pilar Macea** (Aug 2005 – Aug 2006) | Anthony Bellotti | Universidad del Valle, Cali - Colombia | Identification of molecular markers associated with resistance to green mites in cassava |
| **Gabriel A Torres Londoño** (Oct 2005 – Oct 2006) | Anthony Bellotti | Universidad de Caldas, Colombia | Evaluation of *sogatella kolophon* (kirkaldy) and Empohasca bispinata (Davidson & Delong) as possible vectors of cassava frogskin disease. |
| **Victor Hugo Treviño Henao** (Oct 2005 – Oct 2006) | Elizabeth Alvarez | Universidad del Quindio, Colombia | Microbiological, chemical and Physical evaluation of sources of lixiviate residues of plantain and its effects in the management of bacterial wilt (Finca la Manigua) |

**6.2.** List of students supervised in 2006 (continued)
**BSc Thesis**

| Name | Supervisor | University | Title |
|---|---|---|---|
| **Marcelo Vargas** (Feb 2005 – Feb 2006) | Elizabeth Alvarez | Universidad de Caldas, Colombia | Evaluation of ecological practices of soil management and its effect on moko disease of plantain caused by *Ralstonia solanacearum* (Finca La Guaira, Dep. Quindio) |
| **Omar Zuluaga** (Feb 2005 – Feb 2006) | Elizabeth Alvarez | Universidad de Caldas, Colombia | Evaluation of ecological practices of soil management and its effect on moko disease of plantain caused by *Ralstonia solanacearum* (Finca La Cataluña, Dep. Quindio) |
| **Sandra Jimena Valencia** (March 2005 -March 2006) | Cesar Cardona | Universidad Nacional, Palmira – Colombia | Sub – lethal effects of antibiosis on the demography of *Zabrotes subfasciatus* and *Acanthoscelides obtectus*, storage pests of beans. |
| **Anyimilehidi Mazo Vargas** | Anthony Bellotti | Universidad del Valle, Cali - Colombia | Effect of cotton Bollgard® (Bt) on the diversity and abundance of soil arthropods in Cauca Valley. |
| **Laureano Alberto Hernandez Goroy** (Aug 2006- Aug. 2007) | George Mahuku | Universidad Nacional, Bogota – Colombia | Biological control of bean diseases: Investigating the potential biocontrol / plant growth promoting aspect of bacteria isolated from *Morinda citrifolia*. |
| **Angela Iglesias Garcia** (Aug. 2006 – Sept. 2007) | George Mahuku | Universidad del Valle, Cali - Colombia | Identifying and developing molecular markers linked to ALS resistance genes in the Andean genotype, G 5686 |
| **Andres Jenver Matta** (Aug. 2006 – Sept. 2007) | George Mahuku | Universidad del Valle, Cali - Colombia | Identification and development of molecular markers linked to *Pythium* root rot resistance in common bean genotypes MLB 49-89A and AND 1062 |
| **Carlos Fernando Castillo Londoño** (Aug. 2006 – Aug. 2007) | Elizabeth Alvarez | Universidad de Caldas – Manizales | Improvement of nutritional management for the preventive control of rose mildew. |

**6.2.** List of students supervised in 2006 (continued)
**BSc Thesis**

| Name | Supervisor | University | Title |
|---|---|---|---|
| **Adriana Arenas** (June 2006 – June 2007) | Elizabeth Alvarez | Universidad del Valle, Cali - Colombia | Search of resistance sources to blackberry anthracnose in accessions of the Cauca Valley through molecular characterization of isolates of *Colletotrichum* spp. and its host *Rubus glaucus* |
| **Monica Fernandez de Soto** (Dec 2006- Dec 2007) | Lee Calvert | Universidad del Valle, Cali - Colombia | Molecular characterization of resistant and susceptible varieties to the white leaf virus through the use of micro satellite molecular markers. |
| **Alba Rocio Corrales** (Jan 2006- Feb 2007) | Francisco Morales | Universidad del Tolima | Characterization of begomovirus transmitted through whitefly (*belmicia tabaci*) in tomato crops (*lycupersicum esculento*) in the Andean zone departments of Cundinamarca and Tolima |

## 7.0. Problems encountered

In 2006/2007, the overall financial situation of CIAT has affected the PE-1 project, further eroding its very limited core budget. The disease and pest management group of CIAT is a well-recognized group that is making a big difference not only for CIAT traditional commodities, but also in a number of high value crops. Recognizing the strength of the team and the importance of the disease and pest management competency area, in 2005, the group had suggested that this project be made one of the pillars of CIAT. In spite of the fact that this project had received an outstanding review by the Center-Commissioned External Review (CCER) panel in terms of impact, quality of science, publication output, high proportion of grant funding, and other performance indicators, and despite the high demand for the competency area both in the region and internationally, CIAT has made what we think is an unfortunate decision to dismantle the project. The research structure that CIAT has created and implemented in 2007 does not resemble the one recommended by the CCER.

The PE-1 Project staff members have made many contributions. The following are examples of some of these key contributions:

1) developed conventional and molecular tools for detection and diagnosis of major pests and pathogens of various crops;
2) contributed to the development of durable disease and pest resistant varieties;
3) in collaboration with other projects at CIAT, we have developed molecular linkage maps to assist breeding programs to incorporate insect and pathogen resistance;
4) developed novel strategies for disease and pest management;
5) developed microbial and plant-derived biopesticides that are commercially made available by the private sector (this line of research is unique within the CGIAR);
6) made several key discoveries and first reports;
7) produced disproportionately high number of publications (see Figure 1).

The laboratories managed by the disease and pest management competency group are outstanding. For example, the virology laboratory with its facilities and experienced and well-recognized Senior Scientists and the research support staff are considered by many one of the biggest assets that CIAT has. The virology laboratory is often referred as the best in the region. The entomology and pathology research areas are well-respected and productive assets of CIAT. Despite the regional and international recognition of success and impact made by the project staff, it is very difficult to understand the reasoning behind the decision to dismantle this Project through cuts that are disproportionately large and through restructuring that puts it into obscurity. Without consultations with our partners and stakeholders or our clients that we serve, CIAT implemented the following reductions in 2007: Two entomology positions, that were responsible for research on beans, forages and cassava, were lost through the retirement of experienced entomologists. There are few prospects of filling either one of these positions in the near future. An entomologist specializing in belowground pests and soil health left, and the position will not be filled. In addition, an IPM specialist stationed in Tanzania left and the position remained unfilled. And so, today's CIAT with a global mandate on beans, cassava and tropical forages remains without a full time entomologist. The bean pathologist position has been cut in 2007, although one of the major products that the new "bean product line" intends to focus is on biotic stresses. We wonder how this is going to be achieved without a bean entomologist or a bean pathologist. The experienced molecular virologist who has been working on cassava, rice and tropical fruits has been let go. Diversity of experience and disciplines are greatly diminished and with them goes one of the comparative advantages of CIAT in its history in this competency area. The lack of critical mass will further hinder the development of the proposed competency group.

In the area of disease and pest management, we find it difficult to understand the strategy that CIAT is attempting to implement. The lack of a coherent research agenda at CIAT, focused on potpourri of individual special projects rather than on the Center's mission as a whole, has created a problem threatening to erode our binding common goal. The prolonged financial crisis of the Center and the uncertain future that followed has created implausible low staff morale unimaginable even a year ago. It is hard to effectively fight poverty with a demoralized work force.

***Solutions:*** some key solutions can be proposed, but we choose to leave that work to the EPMR.

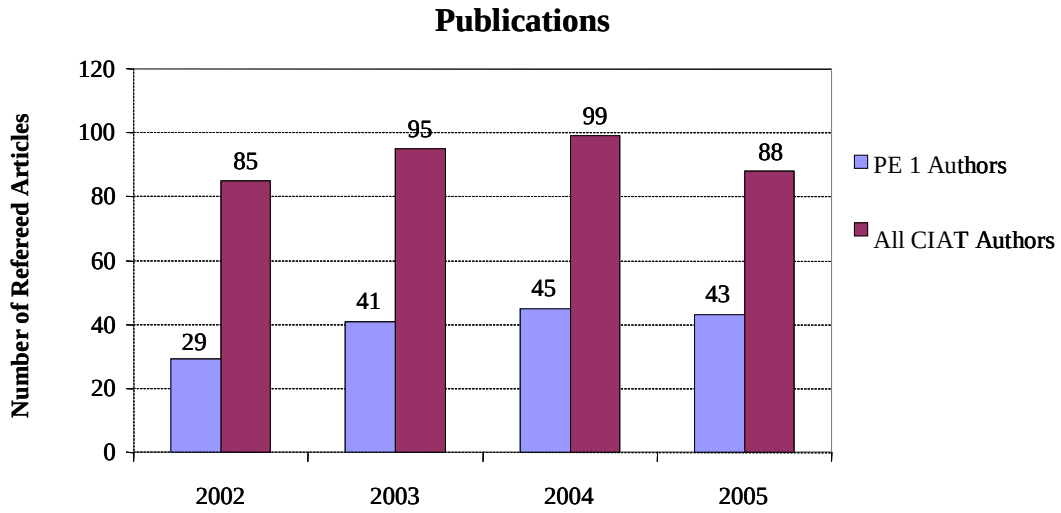


Figure 1. Refereed journal articles authored by one or more scientists of the disease and pest management competency area relative to the total number of articles produced by CIAT in 2002-2005.

## 8.0. Staff list

### Principal Staff

Alvarez, Elizabeth; Pathologist (25%)
Bellotti, Anthony; Entomologist (voluntary contribution)
Buruchara, Robin; Pathologist (35%)
Calvert, Lee; Virologist (30%)
Cardona, César; Entomologist (voluntary contribution)
Correa, Fernando; Pathologist (10%)
Gaigl, Andreas; Entomologist (100%) – left in July, 2006
Kelemu, Segenet; Project Manager and Pathologist (50%)
Mahuku, George; Pathologist (20%)
Minja, Eliaineny; IPM Specialist (80%)- left in 2006
Morales, Francisco; Virologist and Whitefly Project Coordinator (70%)

### Research Associates

Arias, Bernardo; Agronomist (32%)
Mukankusi, Clare; Biologist

### Visiting Scientists

Ortega-Ojeda, Carlos Alberto, Agronomist
Guillaume Cortade
Godwin Ameorphe
Titus Galema

### Research Support Staff

Buah, Stephen; Pathology/Biotechnology Lab. (Africa)
Cadavid, Marcela; Biologist (100%)
Calberto, Germán A.
Cuervo, Maritza; Agronomist/Biotechnology (100%) - moved in 2006 she is in URG
Guerrero, José María; Agricultural Technologist (Acarologist) (50%)
Hernández, María del Pilar; Biologist-Entomologist (100%)
Holguín, Claudia María; Agronomist
Kananura, Patrick; Research Assistant
Llano, Germán Alberto; Agronomist (18%)
Loke, John Bernard; Agronomist (50%)
Male, Allan; Research Assistant, Biotechnology Lab. (Africa)
Martínez, Ana Karine; Biologist
Mejía, Juan Fernando; Agronomist (43%)
Melo, Elsa L.; Biologist (100%)
Mziray, Hendry A; Agronomist
Munera, Diego F., Agronomist (100%)
Ospina, Claudia M; Agronomist (Springtails Taxonomy)
Rodríguez, Jairo; Agronomist

Villareal, Natalia, Biologist (100%)

**Office Staff**

Baguma, Athanasio; Administrative Assistant (Africa)
Escobar, Francisco, Social Communicator
García, Melissa; Administrative Assistant
Nassozi, Sarah, A.C.I.S.; Regional Finance and Administration Officer (Africa)
Tibalikwana, Mabel; Administrative Secretary (Africa)
Zamora, Zulma Lorena C., Secretary

**Technicians**

Acam, Catherine (Africa)
Mendoza, Carmen (left in 2006)
Tobón, Rosalba
Zuñiga, Rodrigo
Nanez, C.

**Field Workers**

Munoz, Adriano
Musoke, Steven, Screen House, Africa
Suleiman, Ssebuliba, Breeding, Africa
Riascos Buenaventura, Rómulo
Rengifo, Herney
Tamayo, Jose
Yela Oscar

## 9.0. Summary budget

### 9.1. Summary 2006 budget

| Source | Amount US$ | Proportion (%) |
|---|---|---|
| Unrestricted Core | 252, 390.00 | 21 |
| Restricted Core: | - | - |
| **Sub-total** | 252, 390.00 | 21 |
| Special Projects | 952,719.00 | 79 |
| **Total Project** | **1,205,110.00** | 100% |

### 9.2. Summary 2005 budget

| Source | Amount US$ | Proportion (%) |
|---|---|---|
| Unrestricted Core | 233,701 | 19 |
| Restricted Core: Colombia | 74,140 | 6 |
| **Sub-total** | **307,841** | 25 |
| Special Projects | 901,231 | 75 |
| **Total Project** | **1,209,072** | 100 |