SUMMARY ANNUAL REPORT

2003

PROJECT PE-1

Integrated Pest and Disease Management in Major Agroecosystems

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

Project PE-1: Integrated Pest and Disease Management

Project Description

Objective: To develop and transfer knowledge systems and pest-and-disease management components for sustainable productivity and healthier environments, through the reduced or rational use of pesticides.

Outputs:
1. Pest and disease complexes described and analyzed.
2. Pest and disease management components and IPM strategies and tactics developed.
3. NARS' capacity to design and execute IPM research and implementation strengthened.
4. Global IPM networks and knowledge systems developed.

Gains: Increased crop yields and reduced environmental damage. Natural enemies of major pests and diseases evaluated. IPM developed, and tested and verified on farms. Increased knowledge of the biology and ecology of pests and diseases and of the damage they cause. Molecular characterization of major arthropod pests, pathogens and diagnostic kits made available for developing durable host plant resistant. FPR methods for IPM developed and implemented. Biological control agents established in new regions. Pests and diseases on additional food and fruit crops evaluated or characterized.

Milestones:

2004 IPM for cassava viruses and root rots implemented. Global communication network for information on soil borne pests operational. Taxonomy on soil borne arthropod pests advanced. Major components for whitefly management in beans and cassava available. Cassava varieties resistant to frogskin disease available. Resistance genes to rice blast incorporated in new varieties. Association of a cassava reovirus and cytoplasm with frogskin disease advanced. Molecular markers tagging resistance to Cassava Bacterial Blight (CBB) available. Germplasm screened for resistance to *Phytophthora* root rot using marker assisted selection. New viruses of snap bean characterized. Biological control through entomopathogens developed for some soil-borne pests. Natural enemies of whiteflies identified. Characterization of cassava reovirus associated with frogskin disease completed. Soil borne arthropod pest complexes identified. Studies on control strategies for bean foliage beetle (BFB) advanced. *Pythium* root rot pathogens in Eastern Africa characterized and their distribution established. ALS and *Pythium* resistance genes in beans characterized.

2005 Complexes of soil borne pests identified. Integrated components for IPM of soil borne pests available for implementation of FRP methods. IPM for CBB implemented. Candidate genes for resistance to CBB on *Phytophthora* root rot of cassava identified. Role of endophytic fungi in plant protection of forages defined. Biocidal proteins of plant origin (e.g. forages) characterized. Brachiaria hybrids resistant to *Rhizoctonia solani* developed. Root rot resistant bean varieties available. Molecular markers for rice hoja blanca virus available. Resistant genes to *R. solani* and rice stripe necrosis virus identified from wild rice species. New Brachiaria hybrids with multiple resistance to spittlebug available. Quantification methods for bean Fusarium root rot pathogen in soil validated. Bean stem maggot tolerant bean varieties evaluated. Botanical and other traditional pesticides for bean pest management evaluated by farmers in eastern and southern Africa. Novel approaches in scaling up bean IDPM technologies evaluated.

2006 New lines resistant to Bean Golden Mosaic virus available. Bean lines combining angular leaf spot and root rot resistance available. Citrus viruses diagnostics available. Molecular markers for pod weevil and Mexican bean weevil identified. *R. solani* resistant genes incorporated in rice. Soil associated microbes with beneficial role on disease management identified. Biological pesticides identified for whitefly control. Participative application of integrated control methods of soil borne pests. Quantification methods for bean *Pythium* root rot pathogens in soil validated.

Users: Information on biodiversity in tropical agroecosystems, improved IPM components and technologies and knowledge systems will benefit NARS scientists, extension workers, farmers and consumers, by increasing crop yields and stabilizing production systems.

Collaborators: IARCs (IITA, ICIPE, CIP, ICARDA, AVRDC); AROs (e.g., CATIE, NRI, Crop and Food Research, BBA, DBT, ETH, IPP, CIRAD, IRD, John Innes Center, CRCTPP); universities (Florida, Wisconsin, Cornell, São Paulo, Caldas, Palmira, Valle); NARS (e.g., EMBRAPA, CORPOICA, ICA, INIAP, INIVIT, MADR, NARO, IDIAP, INTA); NGOs; private industries (ASOCOLFLORES, Palmas de Casanare, Palmar de Oriente, Biotropical); PRONATTA; COLCIENCIAS, SENA, CLAYUCA, FLAR, Profrijol.

CGIAR system linkages: Crops (30%); Saving Biodiversity (20%); Protecting the Environment (40%); Strengthening NARS (10%). Whitefly and Participatory Methods Projects, and Soil Biota, Fertility and Plan Health in the systemwide program on IPM.

CIAT: PE-1 Project Log Frame (2004-2006)

Project: Integrated Pest and Disease Management
Project Manager: Anthony Bellotti

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To increase crop yields and reduce environmental contamination through the effective management of major pests and diseases.	Increased crop yields. Reductions in environmental degradation through adoption of improved technology. Reduction of losses to several major diseases.	Production statistics. Adoption and impact studies. Project reports.	
Purpose To develop and transfer knowledge systems and pest-and-disease management components for sustainable productivity and healthier environments.	Adoption of germplasm with resistance to biological constraints. Establishment of released natural enemies. Use of environmentally friendly control strategies. Improved understanding of major biotic constraints.	End-of-project reports. Refereed publications, book chapters. Adoption and impact studies.	National policies favorable to adoption of IPM strategies (i.e., increased support to extension, reduction of subsidies for pesticides). National programs are active and strong in key countries. Active collaboration from other IARCs and DC research organizations. Active collaboration from AROs.
Output 1 Pest and disease complexes described and analyzed.	Arthropod pests, diseases, natural enemies, and vectors characterized. Host/pest/natural enemy/vector interactions analyzed. Better diagnostic tools available. Biological control agents identified and established. Better understanding of the influence of abiotic constraints in host-pest interactions. Identification of crops (cassava, beans, rice, forages) with tolerance of diseases. Pest and disease distribution (maps) determined.	All areas: project reports, refereed publications, book chapters. Reports with maps, economic damage, biological information. Analysis of experiments. Transfer of tools to seed health facilities. Molecular markers for pest and diseases available. Candidate genes for resistance identified.	NARS have the needed resources. Adequate interaction with other disciplinary scientists. Successful experiments. Continued development of new varieties that are commercially acceptable. Farmers have adequate access to extension agents, credit lines, and other factors that influence adoption. Collaboration with NARS possible. Evaluation, screening, and exploration sites accessible.
Output 2 Pest-and-disease management components and IPM strategies and tactics developed.	Testing of components for effectiveness. Control strategy recommendations clearly identified and crop management practices determined. Farmers test components. Participatory testing, monitoring and evaluation of IPM components with farmers implemented. Guides on IPM strategies published. Disease detection methods available. Web site published.	Analysis of experiments. Guidelines for IPM. Reports on field effectiveness and probability of adoption of components. Field-oriented brochures. Farmer participatory research implemented. Reports available.	Funding for research and technology (IPM) practices available. Stakeholders are willing to participate.
Output 3 NARS' capacity to design and execute IPM research and implementation strengthened.	Training, especially in FPR. Development of projects with NARS. Training materials developed.	Reports on training courses. Concept notes and projects prepared with partners. IPM projects implemented	Trainees are keen to become trainers of farmer communities.
Output 4 Global IPM networks and knowledge systems developed.	Network of researchers established. Preparation of Web pages and databases with relevant IPM information.	Electronically published Web pages and databases. Progress reports.	

SUMMARY ANNUAL REPORT 2003

PE-1 PROJECT

Title: Integrated Pest and Disease Management in Major Agroecosystems.

Inputs:
Investigators:

Anthony C. Bellotti, Entomologist, Project Manager, PE-1
Francisco Morales, Virologist, Whitefly Project Coordinator
Lee Calvert, Virologist
César Cardona, Entomologist
Segenet Kelemu, Phytopathologist
George Mahuku, Phytopathologist
Fernando Correa, Phytopathologist
Rafael Meneses, Entomologist
Elizabeth Alvarez, Phytopathologist
Paul-André Calatayud, Entomologist, Physiologist (IRD)
Robin Buruchara, Phytopathologist (Beans, Africa)
Kwasi Ampofo, Entomologist (Beans, Africa)
Eliaineny Minja, Entomologist (Beans, Africa)
Daniel Peck, Entomologist (Cornell University)
Andreas Gaigl, Entomologist, Soil Pests

Cooperators:
Within CIAT:

Joe Tohme (SB-2)
Hernán Ceballos (IP-3)
Bernardo Ospina (CLAYUCA)
Daniel Debouck (SB-1)
Carlos Lascano (IP-5)
Roger Kirkby (IP-2)
Martin Fregene (IP-3)
Glen Hyman (PE-4)
Nathan Russell (Communications Unit)
Paul Chavarriaga (SB-2)
Eduardo Barrios (PE-2)
James Cock (IP-6)
Jorge Saravia

Budget: PE1

Integrated Pest and Disease Management - Headquarter/Latin America

Source	Amount Us$	Proportion (%)
Unrestricted Core	154,537	12%
Restricted Core	0	0%
Carry over from 2002	40,886	3%
Sub-total	195,423	15%
Special Projects	1,128,773	85%
Total Project	1,324,196	100%

Africa

Source	Amount US$	Proportion (%)
Unrestricted Core	0	0%
Restricted Core	0	0%
Carry over from 2002	0	0%
Sub-total	0	0%
Special Projects	274,547	100%
Total Project	274,547	100%

Research Highlights during 2003

The Integrated Pest and Disease Management Project (PE-1) grew considerably during 2003. CIAT's entomologists, pathologists and virologists have expressed concern that the IPDM project, under its original structure, did not represent all of the ongoing IPM activities at CIAT. CIAT IPDM scientists therefore decided that at least 25% of their time should be represented in the IPDM project (PE-1). This decision was supported by CIAT's Management and in early 2003, the IPDM project was expanded to include all entomologists, pathologists and virologists. The 2003 PE-1 Annual Report includes most all of the IPDM research being carried out by CIAT scientists. Certain research activities, especially those related to host plant resistance, may be reported in the Annual Reports of the different commodity projects.

The Systemwide Tropical Whitefly IPM Project (SPIPM-TWFP) is nearing the completion of Phase II. CIAT has the responsibility to coordinate this project, and its various sub-projects in the Americas, Southeast Asia and Subsaharan Africa. These projects are funded by several donors including: The United Kingdom Department for International Development (DFID); the United States (USAID), New Zealand Agency for International Development (NZAID), the Australian Center for International Agricultural Research (ACIAR). Research and development activities in the subprojects are coordinated by CIAT, IITA and AVRDC. The International Potato Center (CIP) has also participated in the project and currently holds the Chair of the Systemwide IPM Program. During Phase II, some of the most important IPM strategies identified during Phase I, were tested in pilot sites. A whitefly resistant cassava variety, Nataima-31, tested during Phase I, was released by the Colombia Ministry of Agriculture and

Rural Development. Integrated pest management components that include monitoring of whitefly populations, refining action thresholds, developing sampling methodologies and monitoring insecticide resistance for the whitefly *Trialeurodes vaporariorum* have been implemented in the Andean zone. In Central America and Mexico the use of physical barriers or microtunnels by small farmers has proven to give good control of whitefly and aphid transmitted viruses, resulting in considerable economic gains for small farmers. The addition of recently developed resistant varieties will soon be available to farmers.

A meeting of the project coordination was recently held at CABI in the UK. The process for development and funding of Phase III of the SPIPM-TWFP project was initiated.

Development and Formulation of Biopesticides
The increase of cassava production in Colombia and other areas may result in an increase in pest problems. Two of the major economic pests that can reduce yields and starch quality are the cassava hornworm, *Erinnyis ello*, and the burrower bug, *Cyrtomenus bergi*. *C. bergi* can also cause considerable damage on other crops such as peanut, onion and maize. Farmer reaction to outbreaks of these two pests often results in excessive and ill-timed applications of toxic chemical pesticides. Recent research results indicate that biological control through the use of entomopathogens is a viable alternative to pesticides for control of these pests. However, the development and use of “bio-pesticides” is often restricted and not available to producers. CIAT and BIOTROPICAL S.A., a commercial biopesticide company, have developed a collaborative relationship with the objective to research, evaluate, and formulate entomopathogens for commercial purposes. During 2003 two commercial products Bio-Virus and Bio-Rhizium-c to control the cassava hornworm and the burrower bug respectively were made available. The former is a baculovirus isolated from *E. ello*, while the latter is an isolate of the fungal entomopathogen *Metarhizium anisopliae*, identified from the CIAT collection. Both products are commercially available to farmers.

Management of Rice Blast
Managing rice blast trough genetic resistance requires continuous monitoring of pathogen evolution leading to genetic and virulence changes. Resistance genes effective against new pathotypes detected in 2002 and 2003 were identified. Resistance gene combinations effective in controlling Colombian blast populations include Pi-1, Pi-2, Pi-33, and Pi-ta[2]. These resistance genes are being incorporated into different commercial rice cultivars from Latin America through a backcrossing program using greenhouse inoculations, field evaluations, and marker assisted selection. The most effective resistance genes found correspond to those avirulence genes found in higher frequency or of lower rate of mutations in the different genetic lineages of the pathogen. The new reported resistance gene (Pi-9) derived from the wild rice species (*O. minuta*) was tested and found potentially useful for controlling our blast pathogen populations. PCR based molecular markers associated with the durable blast resistance genes identified in our studies have been found and used for the introgression of these genes in our rice germplasm or used for the development of more specific markers such as SNPs. Potential donors of durable blast resistance were identified after continuous evaluations since year 2000 and included in a blast nursery to be distributed to different Latin American breeding programs for their use as progenitors. Near isogenic lines with different resistance genes were developed and are being

distributed to our Latin American partners for the identification of the best genes effective in controlling local blast pathogen populations.

Integrated Control of Subterranean Pests

We identified the key soil pest species in various departments in Colombia. *Clavipalpus* pos. *ursinus* was the most important white grub pest on potatoes and pasture in Cundinamarca. Our results suggest that *Ancognatha scarabaeoides*, an abundant species in this zone, is more a recycler of organic material. *Phyllophaga obsoleta* is an important pest in Antioquia on potato and pasture, and *P. menetriesi* in Risaralda and Quindío on cassava, coffee and maize. These findings will facilitate future control strategies. Moreover, we isolated hundreds of entomopathogenic organisms as potential microbial control agents of soil pests.

IPM in Eastern and Southern Africa with Bean Farmers

Bean IPM farmer groups at project sites in Kenya, Tanzania and Malawi tested a number of traditional and improved IPM strategies by establishing learning and demonstration field plots and organizing a series of field days to evaluate, share and disseminate the results. Some of the farmers have started using combinations of some of the IPM strategies in their individual fields especially improved high yielding and pest/drought tolerant bean genotypes and varieties combined with improved cultural practices. New farmer groups were formed and more farmers were empowered to research, evaluate and demand different services from other stakeholders (market information, seeds, fertilizers, etc.). Cross visits among farmer groups and across villages, districts, sites and countries have enabled farmers to share knowledge, exchange experiences and disseminate IPM information. Farmers have participated in the preparation and testing of leaflets, posters and farmer activity reports that have been prepared by the project for dissemination to the village information centres (VICs) and the wider audience. Some leaflets and posters are in Kiswahili.

Additional Highlights

Cassava Arthropod Pests

- Numerous homopteran species (planthoppers, tree hoppers, froghoppers), the possible vectors of cassava frogskin disease, have been collected from cassava fields in 9 departments in Colombia. The species *Scaphytopus* pos. *fuliginosus* is most frequently observed and an active colony of this species has been established on beans.
- Whitefly samples from Perú and collected from several plant hosts including sweet potato, cotton and weed species, were identified as *Bemisia afer* using RAPD-PCR tests. *B. afer* is an exotic species, introduced from Africa, where it is a serious pest of cassava.
- In collaborative with CIAT's Tropical Fruits Project (IP-6), fruit flies (*Anastrepha* spp) were collected from numerous hosts from several localities in the Colombia departments of Tolima, Valle del Cauca and Quindío. *Anastrepha* species collected include *A. oblicua, A. fraterculus, A. striata, A. grandis* and *A. nunezea.*
- Entomopathogenic nematodes, potential biological control agents for the cassava burrower (*Cyrtomenus bergi*), were collected from several sites in the Colombia departments of Cauca, Caldas and Risaralda. A native species, *Heterorhabditisi* was collected and is being identified by taxonomists.

- Six entomopathogenic nematode species were evaluated in the laboratory for parasitation of *C. bergi*: the species *Steinernema* sp. SNI 0100 (CENICAFE) was the most efficient, causing 100% parasitism and 22% mortality. Results also suggest that *C. bergi* may be capable of an immune response against nematode species.
- The lacewing, *Chrysoperla carnea* (Neuroptera: Crysopidae) was found to be a successful predator of the cassava whitefly, *Aleurotrachelus socialis*. *C. carnea* larvae appear to be more efficient predators than adults and prefer feeding on first and seconds instars of *A. socialis*.
- The cassava variety TMS L.55 from Nigeria contains genes that originated from an interspecific cross between *Manihot esculenta* (cultivated cassava) and *M. glasiovi*. This clone, in laboratory studies, displays resistance to the cassava hornworm, *Erynnis ello*. It is speculated that the hornworm resistance genes comes from *M. glasiovi.*

Plant Insect Pest Interactions

- Preliminary results from one growing cycle show that compared to untreated maize, maize treated with soil insecticides had a lower diversity index of arthropods, decreased presence of Coleoptera and Hymenoptera, and an increased presence of Acarina and Collembola.

Soil Pests: Cassava and other Crops

- Identification of key scarab pest species in Cundinamarca, Antioquia, Quindío, Risaralda: *Clavipalpus* pos. *ursinus* is the most abundant white grub pest in Cundinamarca, *Phyllophaga obsoleta* in Antioquia and *P. menetriesi* in Risaralda and Quindío.
- Isolation of entomopathogenic organisms from white grubs: About 500 fungi, almost 100 bacteria, and 50 nematodes
- An Internet database on subterranean pests has been developed and counts with 35 soil pest researchers, mostly Colombian. In October we will present this database at the 6th Round Table on soil pests in Mexico.
- Collaboration with national and international partner institutions (Universities in Cali, Manizales and Bogotá, Corpoica) and national industry (Biotropical (Medellín), Life Science Technology (LST, Bogotá) working on biological control of subterranean pests has been established.

Bean Entomology

- Finished studies on antibiosis, tolerance, and antixenosis as mechanisms of resistance to *Thrips palmi.*
- A major QTL for *Thrips palmi* resistance was located on chromosome b06. Other minor QTLs for thrips resistance were also located (see SB-2 Report).
- Resistance to the bean weevil (*Acanthoscelides obtectus*) and to the leafhopper (*Empoasca kraemeri*) was identified in *Phaseolus vulgaris* x *P. acutifolius* hybrids.
- Finished studies on the development of a DNA-based molecular marker for resistance to the Mexican bean weevil, *Zabrotes subfasciatus* (see also SB-2 Report).
- Progress was made in the development of molecular markers for resistance to the pod weevil (*Apion godmani*) (See SB-2 Report).
- New lines incorporating insect resistance were developed.
- Monitored the changing situation with whitefly species and biotypes in target areas

- Validated and refined action thresholds for management of the whitefly *Trialeurodes vaporariorum* on snap beans and dry beans.
- Monitored levels of resistance to insecticides in whitefly populations in Colombia and Ecuador.
- Helped in the diagnosis of a new virus disease affecting snap beans in the Cauca Valley.
- Conducted successful screening for sources of resistance to the new virus disease on snap beans.
- Demonstrated the feasibility of producing snap beans with a 70-75% reduction in insecticide use.

Forage Entomology

- A mass rearing of *Aeneolamia reducta* was successfully established. This will greatly facilitate simultaneous evaluation of *Brachiaria* genotypes for resistance to different species of spittlebug.
- Four hybrids showing high levels of antibiosis resistance to *Aeneolamia varia*, *A. reducta*, and *Zulia carbonaria* were identified.
- Several hybrids showing field resistance to *Zulia pubescens* and *Mahanarva trifissa* were identified.
- Studied in detail the mechanisms of resistance to *Aeneolamia reducta*.
- Finalized studies on mechanisms of resistance to five species of spittlebug: *Aeneolamia varia*, *A. reducta*, *Zulia carbonaria*, *Z. pubescens*, and *Mahanarva trifissa.*
- Finalized studies on the effect of simultaneous infestation by two or more spittlebug species on resistance expressions in selected *Brachiaria* genotypes.
- Initiated studies on interactions between strains of five spittlebug species and resistance expression in selected *Brachiaria* genotypes (genotype x species x strain interactions).
- Initiated studies on mechanisms of resistance to adults of five spittlebug species.
- Initiated studies on possible sub-lethal effects of resistance on adults of *Aeneolamia varia.*

Cassava Virology

- After eight years of field trials, we have a solid base to state that the resistance to CFSD is stable and that it holds up under the range of climatic variation that occurs at the screening site. From just the core collection of CIAT, landraces or varieties have been identified for most of the countries where CFSD is endemic and an important production constraint.
- The detection of the CFSV S5 genomic segment is further evidence of the presence of a reolike virus in cassava. It is consistently detected in the CFSD affected plants and is not found in healthy cassava. This is additional evidence that the virus is associated with the disease.
- A diagnostic method based on dsRNA extraction followed by hybridization with the CFSV S5 clone is effective in diagnosing CFSD. The assay takes two days and the technology can be transferred to other facilities with adequate laboratory facilities. The cDNA clone is the positive control in countries where the disease is not present.

Cassava and Tropical Fruit Pathology

- Phytoplasma was successfully detected and identified in FSD-infected cassava roots, leaf midribs, petioles, and peduncles of Manzana (highly affected by FSD) and Catumare (intermediately affected by FSD) using molecular tools and electronic microscopy. Phytoplasma was not detected in healthy plants from the same varieties harvested in Quindío.

A high correlation was found between PCR detection and plants grafted with the cultivar Secundina. Phytoplasma was detected by PCR in the leaves of affected Secundina plants, grafted on plants affected by FSD.

- Suppression of leaf symptoms caused by FSD was successful when cuttings of Secundina and M Bra 383 were rooted in deionized water prepared with 50 ppm chlortetracycline. Nested PCR evidenced the presence of phytoplasma on leaves of affected plants treated with 0 ppm tetracycline.
- After a series of meetings and workshops held in different indigenous communities in Mitú (Vaupés, Colombia), a local committee for agricultural research (CIAL) was created in the Macaquiño community. After participatory diagnosis, the CIAL and the community decided to evaluate maize and rice varieties regarding their adaptation to the traditional slash-and-burn farming system and to local conditions.
- The incorporation into the soil of ashes mixed with organic matter, organic matter alone, and ashes alone increased cassava yields up to 10 t/ha, while crops under traditional management practices yielded 6 t/ha. A farmer participatory research approach was applied and the test sites were indigenous communities located in Vaupés, located in the northern Amazon rainforest, where women grow cassava as a second-cycle crop in small plots of slash-and-burn agriculture that present decreased soil fertility.
- A group of producers, extension agents, private industry and researchers, called the Moko Alliance, seeks to optimize research efforts regarding the control of *Ralstonia solanacearum*, the causal agent of bacterial wilt in plantain and banana. Representatives of each entity forming part of the Moko Alliance attended a countrywide course offered at CIAT. On-farm experiments were established and a proposal was prepared to finance a national research and training program.

Tropical Forage Pathology

- Detection and identification of nitrogen fixing/growth promoting bacteria associated with *Brachiaria*.
- Identification of a bactericidal/fungicidal/insecticidal peptide in seeds of a tropical forage legume.
- Purification and characterization of bactericidal/fungicidal/insecticidal peptide in seeds of a tropical forage legume.
- Development of a PCR-based endophyte detection method in seeds and tissues of *Brachiaria.*

Bean Pathology

- Sources of resistance Identified: Showed that 14 recombinant inbred lines (RILS) from the DOR 364 x G 19833 combine resistance to several *P. griseola* and *C. lindemuthianum* pathotypes, including the most virulent races.
- Research shows that the angular leaf spot pathogen, *P. griseola* co-evolved with its common bean gene pools and exhibits extensive geographical differentiation.
- Characterizing and monitoring pathogen diversity shows co-infection of common bean by different races of *P. griseola* occurs under field conditions.
- The pathotype structure of *C. lindemuthianum* in the departments of Antioquia and Santander, Colombia has changed and new more virulent races have been characterized.

- Molecular evidence that the bean anthracnose pathogen, *Colletotrichum lindemuthianum* coevolved with gene pools defined for common bean.
- Additional evidence was obtained that *C. lindemuthianum* co-evolved with common bean gene pools. This information is important for breeding anthracnose resistance as the strategy of combining Andean and Mesoamerican genes might lead to stable anthracnose resistance
- Host specialization and geographical differentiation for the ALS pathogen, *P. griseola* was elucidated and coinfection on the same leaf and lesion was confirmed under field conditions. Parasexual reproduction might be the way in which *P. griseola* is maintaining high levels of genetic differentiation as well as generate new forms.
- Research on genetic mechanisms in beans shoes that at least three resistance genes condition resistance of G 19833 to four races of *C. lindemuthianum*
- The resistance genes in the bean cultivar G 19833 are distinct from those in the Andean genotypes Michigan dark red kidney, Kaboon and Perry Marrow, and might be a new Andean resistance locus.
- Both dominant and recessive genes with epistatic effects condition resistance to *Phaeoisariopsis griseola*, and the nature of the gene depends on the pathogen race used.
- Angular leaf spot resistance genes were identified and characterized in several genotypes that are potential sources of ALS resistance.
- The germplasm accession, G 19833 was identified as having 2 or three resistance genes for anthracnose. One of these genes appears to be an allele of the Co-1 locus, while the other appears novel.

Africa – Bean Pathology

- Thirty Pythium isolates Uganda and Kenya were characterized by sequencing the ITS1 region of ribosomal DNA and were grouped into 12 species, 7 of which are new additions.
- Distribution maps for Pythium species characterized in Uganda were developed.
- A bioassay method to quantify inoculum of *F. solani f.* sp *phaseoli* confirmed previous observations that FYM increased both dry matter and bean yield but also increased inoculum in the soil. *Calliandra* spp. green manure did not result in such high yields as farmyard manure but did not result in increase in soil population of the pathogen.
- A dilution plating method was developed to quantify total inoculum of Pythium spp in the soil. The method is however limited when focusing on specific (e.g. pathogenic) species as this requires colony identification.
- Neither farmyard manure (FYM) nor Calliandra green manure (GM) had significant impact on *Pythium* populations. FYM increased soil fertility and yield but stores up potential problems for the future in the form of increased pathogen numbers. *Calliandra* spp. green manure may therefore be the preferred choice as part of a series of management practices to reduce the impact of root rots.

Africa – Bean Entomology

- Formal training seminars and informal field training were conducted for farmers, extension personnel and adult education teachers at Kisii in Kenya while representative farmers, extension officers, community leaders and NGO/CBO staff were trained in Tanzania (Hai, Lushoto and Mbeya).

- Participatory project activity planning, implementation, monitoring and evaluation were executed by site stakeholders through meetings organized by farmers and extension personnel in East Africa.
- East Africa farmers are leading the research and extension in conducting different activities and are demanding various services from their local government and community leaders. Researchers, extension, NGOs and other service providers are backstopping farmers' activities particularly in Hai, Mbeya, Lushoto and Kisii.
- Farmers in Kenya and Tanzania have sensitized their community leaders to provide or construct premises for village information centres (VICs) and other ministries have joined in as partners particularly in Kenya (Ministries of Health and Education). The premises are used as village libraries for extension materials and other relevant information.
- Farmers have gone ahead to increase seed of tolerant and high yielding bean types as a source of seed for subsequent seasons and income when it is sold to neighbours or at the local market.
- Some bean farmer groups have united to formed their own Community Based Organisations (CBOs) as in Hai district, or Savings and Credit Cooperative Societies (SACCOS) as in parts of Lushoto and Mbeya (Tanzania).

Problems encountered and their solutions:

- The security situation in Colombia continues to hamper our off station research and farmer related activities. Several regions of Colombia, areas where cassava, beans, rice and tropical forages are grown, are inaccessible. Our Colombia staff, when willing, can visit these sties, but travel for international staff is limited or prohibited.
- The cassava frogskin disease (CFSD), endemic in CIAT and many areas of Colombia hinders research efforts and the movement of germplasm. The development, during 2003, of a diagnostic tool to detect CFSV in cassava germplasm is an important tool for the safe movement of germplasm and facilitates research activities. Lack of funding has hindered progress in CFSD research.
- The funding of research becomes more competitive every year. Lack of core funding has made it difficult to retain qualified and well-trained support staff, to keep continuity in long-term research project, and to expand research or development projects into additional areas.
- Colombia laws for the exporting of arthropods, fungi or other microorganisms for identification purposes, have become more stringent and can hinder needed taxonomic identification of important pests and their natural enemies. Steps are being taken to register all biological collections housed at CIAT.
- Lack of biometrics support at CIAT affects quality of research. The problem is partially solved through agreements with collaborating partners outside of CIAT (Universities, other Institutions).

Plans for next year:

- Evaluate Wild Manihot species for resistance to cassava pests.
- Develop and implement IPM technologies for whiteflies and high valued crops, using participatory research approaches.
- Develop a rapid screening technique for evaluating whitefly resistance in cassava germplasm.
- Support breeding activities aimed at the development of Brachiaria hybrids resistant to spittlebug.

- Development and testing of antisera made from synthetic peptides for CFSV.
- Regional testing of CFSD resistant varieties.
- Documenting of pesticide abuse by small-scale farmers growing high valued crops.
- Promote the development of biological and botanical pesticides with commercial biopesticide industry.
- Characterizing and tagging of disease resistance genes in beans and developing protocols for their use by small farmers.
- Access and understand pathogenicity, characterization, nature of inheritance of resistance, and develop quantity methods for *Pithium* root rots in beans.
- Evaluating effect of green manures and other soil amendments for managing root rot diseases in beans; assess role of associated crops.
- Survey soil pests and their natural enemies for cassava and other crops.
- On farm testing of entomopathogenic fungi and other natural enemies including repellant plants, for burrower bug and white grub control.
- The mapping of Bacterial wilt of plantain in the Amazon Basin to monitour disease incidence (with Land Use Project, PE-4).
- Selection of cassava genotypes resistant to Phytophthora Root Rot and post-harvest deterioration (with Rural Agroenterprises Development Project, SN-1).
- Strengthen collaboration with NARS in Africa and Latin America.
- Prepare and submit publications, attend workshops and conferences.

PROJECT PERFORMANCE INDICATORS: CASSAVA - 2003

1. TECHNOLOGIES, METHODS & TOOLS

1.1. Released Varieties

Nataima-31, cassava variety resistant to whiteflies released by MADR in March 2003.
Frijol CENTA San Andrés.
Bean varieties released in Ethiopia; OMO 95 and “IBADO.”
Bean varieties released in Sudan; Berber Large, RO/2/1,Giza 3, Sarag, Basabeer.

1.2. Genetic Materials Distributed

Nataima-31 cuttings distributed to over 200 cassava producers.

1.3. Elite Material Developed

1.4. Genetic Mechanisms Understood

- Three resistance genes condition resistance in the bean variety, G 19833, to 4 races of *C. lindemuthianum*.
- Resistance genes of the bean cultivar, G 19833 are distinct from other Andean genotypes Michigan dark red kidney, Kaboon and Perry Marrow.
- Both dominant and recessive genes with epistalic effects condition resistance to *Phaeoisariopsis griseola*.
- Antibiosis resistance to spittlebugs (*Aeneolamia varia, A. reducta* and *Zulia carbonaria*) identified.
- Antibiosis, tolerance, and antixenosis resistance in beans to *Thrips palmi* identified.
- Resistance to bean weevil and the leafhopper, *Empoasca kraemeri* identified in *Phaseolus vulgaris* x *P. acutifolius* hybrids.
- Three cassava varieties, MPer 334, MEcu 64 and MPer 273, identified as having resistance to the whitefly, *A socialis.*

1.5. Sources Identified

- Fourteen recombinant inbred lines (RILS) from the DOR 364 x G 19833 cross combine resistance to *P. griseola* and *C. lindemuthianum* pathogens.
- Approximately 30 cassava varieties have been identified as sources of resistance to cassava frogskin disease.
- Two Wild Manihot species, *M. flabelliflora* and *M. peruviana* have been identified as sources of resistance to cassava mites, mealybugs and whiteflies.
- The bean germplasm accession, G 19833 was identified as having 2 or 3 resistance genes for anthracnose.

1.6. Methodologies/Products

- Reliable screening method to establish correlation between nutrients content and resistance to *Phythophthora* root rot in cassava.
- Participatory methods involving farmers and partners developed in East Africa.
- A biopesticide based on a baculovirus developed with a Colombian biopesticide company for control of the cassava hornworm approved by MADR and commercially available.

- An isolate of the fungal entomopathogen *Metarhizium anisopliae* is being developed into a commercial product (Biotropical).
- A diagnostic method based on dsRNA extraction and hybridization that is effective in diagnosing CFSD has been developed.
- A bioassay method to quantify inoculum of *Fusarium solani f.* sp *phaseoli* in beans confirmed.
- Mass rearing methodology for the spittlebug *Aeneolamia reducta* established.

1.7. Rural Development Methods

- Participatory involvement of farmer groups in planning, organizing, implementing, monitoring and evaluating demonstration and learning plot activities in East African villages.
- Farmer field days combined with cross village and cross site farmer visits for knowledge sharing and exchanging experiences (East Africa).
- Setting up village information centres for easy access to extension and other relevant materials on health and education (East Africa).
- Scaling up and scaling out participatory IPM development in Eastern and Southern Africa.
- A local agricultural research committee (CIAL) was created in the Macaquiño community of Mitu to evaluate maize, rice and cassava varieties (Colombia).

1.8. Decision Guides/Support Tools (models/software)

- Leaflets, posters and booklets prepared and tested with farmers in East Africa.
- Farmer activity reports including field days and training seminars (East Africa).
- Leaflet developed on the whitefly resistant cassava variety, Nataima-31, and distributed to farmers.
- Leaflet on the use of a baculovirus product to control to cassava hornworm distributed to farmers.
- An Internet database on subterranean pests developed and made available to researchers.
- Practical Guide for the Management of Cassava Pests, Disease and Nutritional Disorders (with CLAYUCA).

1.9. Data Bases or Maps

- An Internet database on subterranean pests developed and made available to researchers.
- Distribution maps for *Pythium* species characterized in Uganda developed.
- The PE-1 project (IPDM) web page was expanded to include all CIAT IPM scientists.
- Database on arthropod pests of CIAT commodity crops expanded.
- Database Tropical Whitefly IPM project expanded.

2. PUBLICATIONS

2.1. Refereed Journals

Published: 29
Submitted: 21

2.2. Books

2.3. Book Chapters

Published: 4
In Press: 3

2.4. Published Proceedings

Published: 5

2.5. Scientific Meeting Presentations

Presentations: 8

2.6. Working Papers, Other Presentations or Publications

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3. STRENGTHENING NARS

3.1. Training Courses

Organizer	Place	Date	Participants	Received by	Service
MADR – CIAT	Santander de Q. (Cauca)	August 2002	9	Farmers	Integrated pest management practices for the whitefly and frogskin disease
ESPE (Escuela Superior Politécnica del Ejército de Quito-Ecuador/CIAT)	CIAT	30 Aug.- 13 Sept. 2002	17	ESPE (Escuela Superior Politécnica del Ejército de Quito)	Biological control; integrated pest management (IPM) in cassava and beans; conferences combined with laboratory, field and greenhouse studies, and practical techniques; visits to biopesticide laboratories (Laboratorios Laverlam and Productos Biológicos PERKINS)
CLAYUCA-MADR-CIAT	Bucaramanga	3-6 Sept. 2002	40	Technicians, professionals, and local cassava farmers	Intensive training course in modern cassava production, processing, and usage systems in Colombia
Inst. Dominicano de Inv. Agropecuarias y Forestales (IDIAF) y CIAT	Bonao. República Dominicana	28 Oct.- 1 Nov. 2002	87	Farmers, assistants, technicians and researchers	Integrated Pest Management of Rice. Conferences and field practices
MADR – CIAT	Villavicencio, Colombia	12-14 Nov. 2002	93	Farmers, agronomists, assistants and researchers	Integrated Management of rice crop. Conference and field visit.
MADR-CIAT	Suárez (Cauca)	19 Nov. 2002	30	Technicians and local farmers	Workshop on pest management in cassava
Universidad de Caldas	CIAT	27 Nov. 2002	34	Students	Biological control; integrated pest management (IPM) in cassava; visits to laboratories, field plots, and greenhouses
MADR-CIAT	Popayán (Cauca)	29 Nov. 2002	40	Technicians, professionals, and local farmers	Cassava crop management
CIAT – SENA (Armenia)	Sena Armenia	15 Jan. 2003	18	Farmers	Diagnostic of damage caused by white grubs and burrower bug
CIAT	Kawanda in Uganda,	February 2003	15	Participants from SABRN and ECABREN countries	A Marker Assisted Selection short course

Organizer	Place	Date	Participants	Received by	Service
Ministerio de Agricultura-Perú and CIAT	Chiclayo, Perú	8-11 February 2003	113	Farmers, assistants, technicians and researchers	Integrated Management of rice crop. Conference and field practices.
Ministerio de Agricultura-Perú and CIAT	Bagua, Perú	13-15 February 2003	93	Farmers, assistants, technicians and researchers	Integrated Management of rice crop. Conference and field practices.
CIAT	CIAT	20-26 February 2003	5	María P. Quintero, Ana M. Caicedo, Irina Aleán, Cristian Olaya, Elsa L. Melo	Workshop on Identification of Entomoparasitic Nematodes: General Management Issues
CLAYUCA	Puerto Asís-Putumayo	4-8 March 2003	36	Technicians, professionals, local farmers, UMATA officials, officials of the Secretary of Agriculture, NGO officials	Seminar on Integrated Pest Management
CIAT	CIAT	18 February 2003	4	Professor and postgraduate students in science-related areas of the Universidad del Valle	Taxonomy and identification of whiteflies
ICA, Armenia	ICA, Armenia	7 March 2003	40	Agronomists-Phytosanitary Committee	Training course and update in moko disease of plantain and banana in the Department of Quindío
ICA and Fundación Huairasachac	Puerto Asís, Putumayo	10-12 April 2003	25	Agronomist, zootechnicians, and extension workers of NGOs	Integrated pasture management
Universidad de Caldas	CIAT	21 April 2003	6	Postgraduate students in entomology	Biological control applied to cassava
Universidad de Caldas	CIAT	15 May 2003	25	Agronomy students	Cassava entomology and pest control
ICA-CIAT-CORPOICA	CIAT	9-13 June 2003	23	Agronomists, Technicians from ICA and CORPOICA	National course on integrated management of moko disease in plantain
CIAT/ Dr.Ralf- Udo Ehler, Kiel University, Germany)	CIAT	16-20 June 2003	20	Scientists/research assistants/students of the CIAT IPM Unit and other external entities	Use of entomopathogenic nematodes
CIAT	Cali - XXX Congreso Socolen	17-19 July 2003	8	Researchers of the CIAT IPM Unit	Presentation of papers/posters
Universidad de Antioquia	CIAT	15 August 2003	15	Students of the University's Biology Institute	Microbiological Control of Cassava Pests

3.2. Individualized Training

Cuban PhD - INIVIT in Root rot screening methodologies and molecular characterization of the pathogen.

Colombian MSc. **-** Universidad de los Andes. Characterization of *Ralstonia solanacearum* causal agent of bacterial wilt on plantain.

Colombian BSc.- Universidad de Caldas. Integrated management strategies for *Phytophthora* root rot.

Colombian BSc. - Universidad del Valle. Management of moko disease in plantain.

Colombian BSc. - Universidad de los Llanos. Phytoplasma in palm.

CIAT – Elizabeth Alvarez, Iowa State University, July 20 – August 6/03. Detection of phytoplasma by electron microscopy.

CLAYUCA-CIAT-Pedro Molina, March 31 – April 4/03. Training in modern systems of production and processing of cassava.

María Paulina Quintero and César Zuluaga trained at CORPOICA (Rionegro) in the use of entomopathogenic organisms.

Anuar Morales and Rosalba Tobón received training by CORPOICA (Rionegro) in the use of entomopathogenic bacteria. In exchange they trained assistants of this partner institution in the use of EPF.

Colombia-ICA/Bogotá – Mites and Taxonomy.

Colombia-Corpoica-Tibaitatá – Baculovirus/Purification Techniques.

Honduras (3) Government officials – Biological Control applied to cassava.

Bolivia – Spittlebug and soil arthropods/Training in sampling techniques.

Ecuador (3) ESPE (Escuela Superior Politécnica del Ejército de Quito – Whiteflies, hornworm, entomopathogens and mites.

CIAT Human Resource Development Fund - Carlos Julio Herrera/IPM Unit. How to design and manage successful research projects.

CIAT - María del Pilar Hernández/IPM Unit - The Egyptian International Centre for Agriculture - Training Course on Integrated Pest Management. Egypt, July 10 - September 25/03.

Colombia CORPOICA-Bogotá - Trained (1 week) in Técnicas para la Conservación de Microorganismos a Largo Plazo (Ligia Dense, Juliana Rojas, Ana Maria Serralde and Patricia Hernández).

Colombia (Student Universidad del Valle, Cali) has started work on infection process of Phaeoisariopsis griseola. (Monica Navia Urrutia).

Two nationals from Tanzania and Rwanda were trained at Kawanda on MAS and bean pathology practices respectively.

Two Hai women farmers each represented their district/national farmer groups in two separate regional workshops in June and July (Science and Technology in Agriculture and Regional Priority Setting for ECABREN).

3.3. PhD, M.Sc. and pregraduate thesis students

PhD: 4 - **Completed:** 1
M.Sc.: 6 - **Completed:** 1
B.Sc.: 13 - **Completed:** 2

3.4. Workshops, Meetings and Seminars

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3.5. Technical assistance

- Numerous field trips and meetings with NARS in South America (Colombia, Panama, Ecuador, Brazil, Cuba, El Salvador, Mexico, etc.) Asia (Thailand) and Africa (Kenya, Uganda, Tanzania and others) on CIAT commodity crops, beans, cassava, rice and tropical pastures.
- Field (consulting) visits by CIAT IPM specialists on additional crops that include: rubber plantations, oil palm plantations, orchid and cut flower growers, vegetable producers (tomatoes, peppers, onions, etc.), field crops (maize), fruit crops, plantains, etc.

3.6. ARO Research Partnerships

Universities: Florida, Cornell, Iowa State, North Carolina State - USA
University of Queensland - Australia
Crop and Food Research - New Zealand
Royal Veterinary and Agricultural University
Hannover University, Kiel University, BBA - Germany
Ing. Gloria Esparanza Santana, CORPOICA Rionegro, Antoquia, Colombia
Ing. Carlos Manuel Araya, National University, Heredia, Costa Rica
Dr Andre Levesque, Agriculture and Agri-Food Canada, Ottawa
Dr. Jean-Pierre Busogoro, Agricultural University of Gembloux, Belgium
University of Nairobi, Makerere University, Moi University, Bunda College, University of Alemaya, Sokoine University, University of Zimbabwe - Africa
Food and Agriculture and Agri-Food - Canada
Central Science Laboratory, University of York, UK
Horticultural Research International (HRI) - Wellesbourne

4. RESOURCE MOBILIZATION

4.1. Proposals funded

- Detección y manejo de microorganismos asociados con Cuero de Sapo en yuca: **MADR**
- Avance en el desarrollo de tecnologías de cultivo y postcosecha para una producción rentable y sostenible de guanábana (*Anona Muricata* Lynn) Fase 2: **FONDO DE COOPERACION ESPAÑOLA**
- Identification of a phytoplasma associated to Lethal Wilt in oil palm. **Palmar del Oriente, Palmas de Casanare and Palmeras Santana.**
- Caraterización molecular de un fitoplasma que esta afectando el cultivo del lulo en Colombia. **ICA.**
- Scaling up and scaling out bean IDPM promotion activities including pest tolerant and improved high yielding bean genotypes. **(extension phase to DFID)**.
- Bean root rot disease management in Uganda. **(extension phase to DFID)**.
- Pan-Africa Bean Research Alliance, **CIDA** (Canada).
- Epidemiology of bean root rots, HRI (from **DFID**).

- Genetic Improvement of Bush and Climbing Beans, **Rockefeller Foundation.**
- Pan-Africa Bean Research Alliance, **SDC (Switzerland).**
- Eastern and Central Africa Bean Research Network, **USAID (USA).**
- Sustainable Integrated Management of Whiteflies through Host Plant Resistance; **NZAID (New Zealand).**
- Understanding the mechanisms of plant resistance to whiteflies; **USDA/USAID (USA).**
- Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses in the Tropics. Phase 2 - Network Strengthening, Pest and Disease Dynamics and IPM Component Research. **DFID.**
- Genetic Improvement of Common Beans Using Exotic Germplasm and Biotechnology. **ABOS-Gent.**

4.2. Proposals and concept notes written and submitted

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4.3. Resource mobilization activities

Contacts and Meetings with USAID, USDA, MADR, Rockefeller Foundation, IFAD, FAO, SDC, CIDA, DFID, COLCIENCIAS, Oil Palm Growers, DANIDA, ASOCOLFLORES, Fondo de Cooperación Española, SOHOFRUCOL, PRONATTA, ARD-CAPP

5. IMPACT MONITORED

As a pilot impact assessment study continue to be carried out in Uganda, six partners have been trained in impact assessment.