

SUMMARY ANNUAL REPORT

2004

PROJECT PE-1

Integrated Pest and Disease Management in Major Agroecosystems



PROJECT PE-1: INTEGRATED PEST AND DISEASE MANAGEMENT

1. 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 frog skin disease available. Resistance genes to rice blast incorporated in new varieties. Association of a cassava reovirus and cytoplasm with frog skin 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 frog skin 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.
- 2007 Biological pesticides for soil borne arthropod pests and plant diseases available. IPM of soil borne arthropod pests implemented. Methodologies for evaluating effect of transgenic crops (Bt) on non-target species developed. Whitefly IPM implemented on selected crops (beans, snap beans, cassava). Brachiaria hybrids resistant to rhizoctonia foliar blight developed. Gene for antifungal protein cloned from tropical forage clitoria and characterized for use in transgenic plants. Rice blast resistance genes incorporated into Latin American rice commercial cultivars. Method to quantify Pithium and Fusarium root rot pathogens in soil validated. Pithium root rot pathogens in Eastern Africa characterized and distribution established. ALS and Pithium resistance genes characterized and deployed in improved varieties. A molecular detection assay for bacterial blight of common bean implemented. Identification of resistance sources of phytoplasm associated to Cassava Frog skin Disease using molecular markers.

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 Plant 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
<p>Goal <u>To increase crop yields and reduce environmental contamination through the effective management of major pests and diseases.</u></p>	<p>Increased crop yields. Reductions in environmental degradation through adoption of improved technology. Reduction of losses to several major diseases.</p>	<p><u>Production statistics.</u> Adoption and impact studies. Project reports.</p>	
<p>Purpose To develop and transfer knowledge systems and pest-and-disease management components for sustainable productivity and healthier environments.</p>	<p>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.</p>	<p>End-of-project reports. Refereed publications, book chapters. Adoption and impact studies.</p>	<p>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.</p>
<p>Output 1 Pest and disease complexes described and analyzed.</p>	<p>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.</p>	<p><u>All areas: project reports, refereed publications, book chapters.</u> 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.</p>	<p>NARS have the needed resources. Adequate interaction with other disciplinary scientists. <u>Successful experiments.</u> 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.</p>
<p>Output 2 Pest-and-disease management components and IPM strategies and tactics developed.</p>	<p>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.</p>	<p>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.</p>	<p>Funding for research and technology (IPM) practices available. Stakeholders are willing to participate.</p>
<p>Output 3 NARS' capacity to design and execute IPM research and implementation strengthened.</p>	<p>Training, especially in FPR. Development of projects with NARS. Training materials developed.</p>	<p>Reports on training courses. Concept notes and projects prepared with partners. IPM projects implemented</p>	<p>Trainees are keen to become trainers of farmer communities.</p>
<p>Output 4 Global IPM networks and knowledge systems developed.</p>	<p>Network of researchers established. Preparation of Web pages and databases with relevant IPM information.</p>	<p>Electronically published Web pages and databases. Progress reports.</p>	

SUMMARY ANNUAL REPORT 2004 PE-1 PROJECT

Title: Integrated Pest and Disease Management in Major Agroecosystems.

2. Project Inputs:

CIAT Staff List:

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
Elizabeth Alvarez, Phytopathologist
Andreas Gaigl, Entomologist, Soil Pests
Robin Buruchara, Phytopathologist (Beans, Africa)
Eliaineny Minja, Entomologist (Beans, Africa)

International Contributing Staff

Daniel Peck, Entomologist (Cornell University)
Paul-André Calatayud, Entomologist, Physiologist (IRD)

(Within CIAT)

Rafael Meneses, Entomologist
Kwasi Ampofo, Entomologist (Beans, Africa)
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)
Paul Chavarriaga (SB-2)
Eduardo Barrios (PE-2)
James Cock (IP-6)
Nathan Russell (Communications Unit)
Jorge Saravia

List of Partners - Local

Collaborators: Other Institutions

CENICAFE, Chinchiná, Colombia – Juan Carlos López, Alex Bustillo, Gabriel Cadena
Universidad de Caldas, Manizales, Colombia – Arnubio J. Valencia
BIOTROPICAL S.A., Medellín, Colombia – Guillermo León Hernández
CORPOICA “La Libertad” (Villavicencio, Dr. Aníbal Tapiero)
Corporación para el Desarrollo Sostenible del Norte y Oriente Amazónico (CDA, Vaupés, Dr E. Polo and R. Peña)
CRIVA—Consejo Regional Indígena del Vaupés (Mitú)
ICA—Quindío and Valle (Drs E. Vargas, F. Varón, and C. Huertas)
Magro S. A.
Secretaría de Agricultura del Vaupés (at Mitú, Dr G. Arbeláez)

Special (La Tebaida, Mr. S. González)
UMATAs (Drs. O. Holguín, L. Muñoz, and W. Ospina)
Universidad de Caldas, Manizales
Universidad de los Andes, Bogotá
Universidad del Valle, Cali
Agrobiológicos SAFER (Natural Control), Medellín
Hacienda San José S.A., Palmira

International

Iowa State University (Dr. T. Harrington, Dr. T. Pepper)
Kansas State University (Dr. Robert Zeigler)
Cornell University
Syngenta (Dr Germán Hoyos)
FIAFOR – Panamá – José Antonio Aguilar
University of California Davis, Davis, USA – Patricia Stock
University of Florida, Gainesville, USA – Jorge Peña, Gregory Evans
Systematic Laboratory in Livingston, Montana, USA – Mike Rose
USDA - United States Department of Agriculture, USA - Stephen L. Lapointe

Collaborating Institutions

INRA-INSA, Laboratoire de Biologie Appliquée, Villeurbanne, France
IRD, France
CNPMP, EMBRAPA, Brazil
IAC, Sao Paulo, Brazil
USDA, Beltsville MD, Fort Pierce, FL - USA
Cornell University, USA
Crop and Food Research Institute, New Zealand
British Museum
INIA – Instituto Nacional de Investigación Agrícola – Anzoátegui, Venezuela
Ministerio de Agricultura y Desarrollo Rural, MADR, Colombia
CORPOICA, Nataima, Colombia
Universidad Nacional, Bogotá, Colombia
Universidad Nacional, Palmira, Colombia
Universidad de Antioquia, Medellín, Colombia

Linkages with Other CIAT Projects and with CIAT's Partner Institutions

IPRA, based at CIAT, Colombia (Participatory Research), SN-3
Conservation and Use of Tropical Genetic Resources SB-2, SB-1
Improved Cassava for the Developing World IP-3
GIS, PE-4
Beans, IP-1
Forages, IP-5
TSBF
Rice, IP-4
Tropical Fruits, SB-3
Beans/Africa, IP-2
Soils, PE-2
Information for Development, SN-4
Instituto Agronómico de Campinas (IAC), Brazil
Instituto de Investigaciones de Viandas Tropicales – INIVIT, Cuba
Universidad Nacional de Colombia, Sede Palmira, Colombia
EMBRAPA, Cruz das Almas, Brazil
Escuela Politécnica del Ejército (ESPE), Ecuador

List of Partners – Africa

National Research and Extension Programmes	NGOs	Other Projects	Policy Makers and Local Leaders	Community Based Organizations
Uganda	CARE, AfriCare	Root rot project NARO-Farm Africa project, AHI	District, county and village leaders	Farmer group associations, Church Women groups
Kenya	CMAD, Winrock?	Farm input promotion (FIPS) project, Root rot	Director KARI Kisii, DAEO- Homabay, Chiefs and sub-chiefs, District Education and Health coordinators	Women groups, Adult education teachers association, Church groups
Tanzania	World Vision, Farm Africa, Adventist Dev and Relief Agency, Agric. development trusts in Mbeya	AHI, ERI, ECABREN Project on climbing beans, Armyworm IPM Project	National, regional, district, ward, division and village levels	Farmer group associations, Women groups
Malawi	PLAN International, Cocern Universal	ERI, SABRIN Projects	National, district, ward, division and village levels	Bembeke Smallholder Growers' Associations, Women groups

Budget: Integrated Pest and Disease Management - PE1

Headquarter/Latin America:

Source	Amount US\$	Proportion (%)
Unrestricted Core	229,195	17%
Restricted Core	105,454	8%
Carry over from 2003	168,377	13%
Sub-total	503,026	38%
Special Projects	808,933	62%
Total Project	1,311,959	100%

Africa:

Source	Amount US\$	Proportion (%)
Unrestricted Core	0	0%
Restricted Core	0	0%
Carry over from 2003	0	0%
Sub-total	0	0%
Special Projects	272,852	100%
Total Project	272,852	100%

3. Research Highlights

The Integrated Pest and Disease Management Project PE-1, is presently staffed by 12 Senior Scientists; ten located at CIAT Headquarters in Palmira, Colombia and two out posted in East Africa working on beans. All these scientists have approximately 25% of their time in Project PE-1. Most have the majority of their time assigned to one or more of the commodity projects, rice, beans, cassava, tropical forages and tropical fruits. In addition to the research activities involving CIAT's traditional commodity crops, IPDM scientists are also involved in projects that expand our expertise to other agricultural crops. These include maize, cotton, onions, asparagus, other vegetables, potatoes, cut flowers and oil palm. Some of the activities being carried out on these crops are described in this Annual Report. The 2004 PE-1 Annual Report contains a description of a major proportion of the IPDM research being achieved by CIAT scientists. However, several research activities, especially those related to host plant resistance, are more often reported in the Annual Reports of the different commodity projects. Funding for research carried out on non-CIAT crops (as mentioned above) is always provided through special projects.

CIAT has determined to structure many of its activities and projects around three central themes, referred to as "Development Challenges;" these are Sharing the Benefits of Agrobiodiversity, Overcoming Land Degradation and Enhancing Rural Innovation. IPDM scientists are actively involved in all three challenges and have assisted in developing project proposals in Agrobiodiversity and Land Degradation.

The CIAT IPDM project has played a major role in the formation and development of the CGIAR Systemwide Program in IPM (SP-IPM). It has been represented at all of the Annual Meetings since the inception of this group. CIAT is the Convening Center for the major ongoing project in the SP-IPM, The Tropical Whitefly IPM Project. At present a project is being developed on "Soil Biota, Fertility and Plant Health." Two meetings on the development of this project were held during 2004, one at CIMMYT in Mexico, and the second at CABI in the UK. A project proposal is being developed and CIAT will probably be the convening center for this project.

The IPDM Project, at present, houses the BMZ financed project on "Integrated Control of Subterranean Pests in South America." This project, led by a German Scientist, provides added expertise and support for CIAT's role in the SPIPM project on "Soil Biota, Fertility and Plant Health."

The second phase of the System wide Tropical Whitefly IPM project (SP-IPM-TWFP) has now been completed. CIAT is the convening center for the coordination of this project and interacts with its various subprojects in Africa, Asia and Latin America. The United Kingdom Department for International Development (DFID) was the major source of funds for this second phase (other funding partners included USAID, USDA (USA), NZAID (New Zealand) and ACIAR (Australia). Discussions are presently underway with DFID for continued funding into the third phase of this highly successful project. A book on the activities and achievements during the first phase of this project is now ready to go to press and should be published during early 2005. Additional information and results, especially on the second phase of the project are detailed in the PE-1, 2004 Annual Report.

The Instituto Agronómico de Colombia (ICA) has invited the CIAT IPDM project and 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. We are in the process of negotiating this collaboration with ICA.

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 CIAT IPDM Project (PE-1) provides a service for the identification of arthropod pests collected from various crops, but especially from CIAT's mandated crops, and related activities. We have contact and active collaboration with more than 40 international taxonomists. 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.

In addition, the IPDM project also maintains a "cepario," a collection of entomopathogenic fungi, bacteria and nematodes. 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. Assistance in the identification of these organisms is provided by Cornell University (USA), the Federal Biological Research Center for Agriculture and Forestry (BBA) and Kiel University (Germany) as well as other institutions.

IPDM Web site

The CIAT-IPDM (Project PE-1) web site has been in operation since 2002. The web site offers immediate access to information and research activities in pests and diseases of CIAT's mandate commodity crops and links to other CIAT projects as well as other institutions, universities, IPM organizations, etc. outside of CIAT.

The Web site receives an average of about 2000 visits per month with the peaks occurring in May and September. The most visited pages are the Home page, publications, training and highlights. In addition, there are almost five times more downloads than pages visited, confirming a general tendency that users find products mainly through search engines, like Google. This supports our strategy of publishing the results of our research on-line. The most downloaded documents are Student Thesis, Annual Reports and Joint Publications (e.g. a course with CORPOICA, with CIAT scientists participation).

Africa Highlights: Beans

Bean farming communities and partners at project sites in Uganda, Kenya, Tanzania and Malawi have appreciated and fully participated in project activities. Policy makers, local leaders and other project partners have been particularly happy with the participatory group approach and processes that different farmer groups have developed and used in the learning by doing and dissemination of technologies that were developed by the groups. Farmers seem to be very keen to experiment and learn together in groups about more new technologies each season.

Participating farmers are also happy to train other farmers and visitors on their achievements and failures. When farmers fail in one activity, they quickly search for alternatives and try them out.

Awareness creation has spread further to new districts and locations in each country and service providers are happy because they can reach more farmers in groups (with farm inputs, credits and other production services). This has resulted in new farmer groups at project sites in the four countries and scientists in non project participating countries are requesting for promotional materials, linkage and financial support to enable them participate in project activities. Policy makers at different levels are now using the farmer groups as a vehicle for promotion of other activities in health, education and other community planning and development activities.

Project partners at different sites have been very instrumental in the dissemination and ownership of some of the project activities. For example, preparation and dissemination of extension materials and bean seeds for demonstrations, facilitation of farmer cross visits and national scientists in different activities, formation and registration of farmer groups, etc. Linking project activities to those of AHI, Farm Africa, ADRA, ERI, ECABREN, SABRIN, PRIAM, Farm Input Promotion Africa (FIP in Kenya) project, Armyworm IPM project, World Vision, Concern Universal, AFRICARE, CARE, PLAN International, etc. have enabled sharing of costs and helped to reach more new farmers together.

Visits to project participating farmer groups by donor representatives, the CIAT Director General, different scientists, policy makers, and fellow farmers from various sites and locations have greatly motivated farmers to think about their own development. This has resulted to farmers in each country feeling free and confident to constantly request for additional services to solve different problems (e.g. access to more bean germplasm and improved seed, training in quality seed production, formation of savings and credit accounts, continued use of effective indigenous knowledge, market information, training group dynamics, etc.). Farmers' confidence in the use of indigenous knowledge has been restored and farmers are freely contributing their indigenous knowledge in farmer meetings and field days.

Additional Highlights

Cassava Arthropod Pests

- Techniques and methodologies developed for rearing two Cicadellidae species, *Empoasca bispinata* and *Scaphytopius marginelineatus* on cassava; both species being evaluated as possible vectors of CFSD.
- Biology and ecology of *Scaphytopius marginelineatus* feeding on cassava determined. Egg to adult duration, including five nymphal instar stages, averages 40.5 days and adults can survive for 60 days.
- Homopteran species, *S. marginelineatus* evaluated as a possible vector of CFSD; Nested PCR analysis confirmed that amplified insect products are related to the phytoplasm associated with CFSD found in cassava.
- Research on determining plant metabolites involved in whitefly (*Aleurotrachelus socialis*) resistance in cassava genotypes initiated through joint CIAT USDA project funded by USAID. Procedures for immunization and production of antibodies were identified and protein sample concentration for good visualization of protein bands were determined.

- *Jatropha gossypifolia* (Euphorbiaceae) extracts shown to be toxic to three Lepidoptera species (*Busseola fusca*, *Ostrinia nubilalis* and *Sesamia nonagrioides*); these are important pests of Maize in Africa, Europe, North America and Mediterranean countries. It is considered that the toxic compounds are probably proteins and these can be studied to develop improved pest resistant plants by transgenic strategies.
- The biology and development of the “B” biotype of *Bemisia tabaci* was evaluated on two African cassava genotypes (MNg 11 and MNg 2), resistant to Africa Cassava Mosaic Disease (CMD), in the laboratory at CIAT. Results on longevity, fecundity, development time, survival rate and demographic parameters suggest that genotype MNg 11 (TMS 60444) is not a suitable host for biotype B of *B. tabaci* collected in Colombia.
- Studies on the biology and development of the “B” biotype of the whitefly *Bemisia tabaci* feeding on the wild *Manihot* species *M. flabellifolia* indicate that the latter is a potential source of whitefly resistant genes. Female survival averaged only 3.5 days and only 8% survived. In previous research, *M. flabellifolia* also expressed resistance to cassava mites, mealybugs and the whitefly species *Aleurotrachelus socialis*.
- The African cassava genotype TMS 60444 (MNg 11) developed from an interspecific cross with *M. glaziovii*, for resistance to African Cassava Mosaic Disease (CMD) also displays high levels of resistance to cassava hornworm (*Erinnyis ello*). Previous evaluations of *M. esculenta* genotypes did not identify hornworm resistance. It is therefore assumed that the genetic resistance originates from *M. glaziovii*.
- Arthropod pest evaluations of cassava genotypes from the Cassava Germplasm Improvement Program on the Atlantic Coast of Colombia, show that the mite *Oligonychus peruvianus* was the major pest during the 2003-2004 crop cycle.
- Isolation of a Bacteria (possibly a new species) close to *Bacillus thuringiensis* living in the gut of a new nematode species found in association with *C. bergi*, the cassava burrower bug.
- Isolation of a protein toxic to the cassava mealybug *Phenacoccus herreni*, from the Euphorbiaceae species *Jatropha gossypifolia*; this could be useful in genetic control of the mealybug and other pest species.
- Detection of proteins potentially involved in resistance of cassava to the whitefly, *Aleurotrachelus socialis* in resistant cassava genotypes.

Plant/Insect Biodiversity Interactions

- These studies have identified a high abundance and diversity of soil-active and surface-active fauna associated with the cotton crop under the conditions of the Cauca Valley, Colombia.
- Pitfall traps are an appropriate method for measuring the abundance of surface-active arthropods and comparing their activity and diversity across treatments.
- Extracting soil cores with berlese funnels is an adequate method for measuring the abundance of soil-active arthropods and comparing their activity and diversity across treatments.
- In the two-cycle maize studies a total of 11,850 arthropods were captured and sorted from pitfall traps. These were identified to 16 orders comprising five classes. Of total specimens captured, 71.4% were from the first growing cycle (2002B) while 58.7% were from the insecticide treatment.
- The most abundant class was Collembola, with 46.0% of total individuals captured, and the least abundant was Chilopoda with 0.25%. Among the 16 orders, Collembola

(taxonomically considered at both the class and order level) and Acari were the most abundant with 45.9 and 19.7% of captured individuals, respectively.

- In the case of cotton, in the first cycle (2003) 438,934 specimens were captured in pitfall traps, representing 20 orders in 8 classes. The most abundant class was Collembola with 52.3% of total individuals captured; 54.3% of these were associated with transgenic cotton and 45.7% with conventional cotton.
- The response of the most abundant group, Collembola, is currently being investigated and described in more detail thanks to a collaboration with the National University of Colombia in Bogotá. Springtails are being mounted and identified to genus-species to increase the resolution of our interpretation of this group in terms of taxonomic and functional diversity. At present, 12 genera from eight families and three orders have been identified. The order Poduromorpha is most abundant with 96.5% of the total captured individuals. At the genus level, *Brachystomella* has only been detected in pitfall traps and *Cyphoderus* only in soil samples.
- A taxonomic key for identification of families of Collembola that are associated with cotton and maize in the Cauca Valley has been developed. In addition the reference collection housed at CIAT for Collembola is now available for researchers interested in this taxonomic group.
- A photographic reference collection representative of the type species of the Collembola group (Habitus) has been developed and is available; these photographs are also available on the CIAT IPDM Web page.

Soil Pests: Cassava and other Crops

- A highly promising strategy for the integrated control of the burrower bug *Cyrtomenus bergi* has been developed. The combination of the entomophagous fungus *Metarhizium anisopliae* and the systemic insecticide imidacloprid in sublethal dose caused a mortality of 87%.
- We described for the first time in Colombia the native entomopathogenic nematode *Steinernema kraussei*. We isolated this nematode from soils taken from a Guamo field near Manizales and from a cassava field in Santander de Quilichao (Colombia).
- The phenology of key scarab (white grubs) species have now been described for three ecoregional zones of the Department of Antioquia (Colombia); about 200,000 scarab beetle specimens have been collected.
- We described the life cycles of three key scarab pest species (*Phyllophaga menetriesi*, *Phyllophaga* sp., and *Anomala inconstans*). These studies are highly important for the development of control strategies, and to develop laboratory colonies for studies on biological control.

Bean Entomology

- Resistance to the bean weevil (*Acanthoscelides obtectus*) was identified in *Phaseolus vulgaris* x *P. acutifolius* hybrids.
- Finished studies on molecular markers for *Thrips palmi* resistance.
- Progress was made in the development of molecular markers for resistance to the pod weevil (*Apion godmani*).
- New beans accessions and lines with insect resistance were identified.
- Detected important changes in whitefly species composition in the target area.

- Detected varying levels of resistance or susceptibility to some of the insecticides commonly used for whitefly control in the target.
- Initiated diffusion of technology activities within the DFID-funded project on Sustainable Management of Whiteflies.
- Conducted successful screening for sources of resistance to the new virus disease affecting snap beans.

Forage Entomology

- Mass rearings of *Zulia carbonaria* and *Prosapia simulans* were successfully established.
- New sexual hybrids with high levels of antibiosis resistance to *Aeneolamia varia*, *A. reducta* and *Zulia carbonaria* were identified.
- 11 apomictic hybrids “pre-selected” for Mexican conditions showed high levels of antibiosis resistance to *Prosapia simulans*, one of the most important spittlebug species affecting *Brachiaria* in Mexico and Central America.
- The resistance of 22 sexual hybrids to *A. varia*, *Z. carbonaria*, *Z. pubescens* and *Mahanarva trifissa* was confirmed in replicated field trials conducted in Caquetá.
- Finalized studies on the effect of host plant resistance on the demography of *Aeneolamia varia*.
- Initiated studies on the effect of host plant resistance on the demography of *Zulia carbonaria*.
- Initiated studies on mechanisms of resistance to *Aeneolamia albofasciata*, *A. postica*, and *Prosapia simulans* in Mexico.
- Initiated studies on mechanisms of resistance to *Deois incompleta* and *Notozulia entreteriana* in Brazil.

Bean Entomology: Africa

- One hundred and thirty-four *Pythium* isolates from areas affected by bean root rots in Kenya and Rwanda were characterized by sequencing the ITS-1 region of ribosomal DNA and grouped into 22 species of which nine are new additions.
- Distribution maps for *Pythium* species characterized in Kenya and Rwanda were developed.
- Some of the *Pythium* species pathogenic to beans induced symptoms on and affected sorghum, millets, field peas and maize major crops grown in association with beans in south western Uganda.
- Some of the components useful in the integrated management of bean root rots were effective in reducing root damage and in increasing yield parameters on sorghum, millets, field peas and maize in bean based cropping system.
- The participatory farmer research group approach for pest and disease management activities have spread to wider and new areas; these methodologies include farmer meetings, field demonstrations combined with field days and exchange visits, promotional materials, farmer activity reports, village information centers, small seed packets, seed displays and exchanges, visits to farmer groups, radio, etc. and are proving to be very effective tools in getting the message to bean farming communities. Pilot sites are now located in Malawi, Tanzania, Kenya, Uganda, DR Congo and Rwanda. These are approximately 24 “Satellite sites” and the technology is reaching about 19,000 farmers, and it is estimated that more than 45,000 farmers are now aware of the bean IPDM message.

Cassava Virology

- The CFSV PCR detection method identifies all the CFSD isolates that have been tested to date.
- The genomic segments of CFSV S1 and S4 can be detected directly without PCR amplification.
- More of the genome of CFSV has been cloned. We have cDNA clones for the genomic segments S1, S4 and S5. The most closely related virus is rice ragged stunt virus.

Cassava Pathology

- Association of phytoplasmas with Frogskin Disease, was confirmed, through DNA amplification with specific primers, designed recently, based on the sequence obtained in previous amplification by nested PCR. The phytoplasma was classified as X-Disease group. Cells characteristic of phytoplasmas were detected in root phloem, by electron microscope. The phytoplasma structures observed were pleomorphic, comprising round, elongate, dumbbell, and ring-shaped elements, mostly 150 to 250 nm wide and 1000 nm long. The phytoplasma structures were limited only to phloem tubes and were never seen in large quantities. A phytoplasma was also detected in the insect *Scaphytopius marginelineatus* (Homoptera), trapped on cassava plants. Two DNA sequences of the Phytoplasma detected in cassava roots affected by Frogskin Disease, were reported to GenBank, which gave them accession numbers AY737646 and AY737647.
- Fifty-two isolates of *Ralstonia solanacearum* were obtained from samples of plantain affected by Moko, conserved, identified by PCR. Races and biovars were identified by pathogenicity and biochemical analysis. Representative strains of *R. solanacearum*, selected and available for: a, design of PCR primers to detect the pathogen; b, genetic crop improvement; c, selection of control practices. DNA sequences were reported in GenBank. New ecologically friendly practices were identified in greenhouse trials for the control of *R. solanacearum*. Marigold (*Tagetes patula*) incorporated in the soil was a most effective treatment, reducing the bacterial population by 84.8%. The bacterial populations in the soil were also reduced by lixiviate of plantain compost (55.8%), calfos (39.3%), and Fulvan® (36.7%), whereas the control with no application had a reduction of 50%.
- First report of phytoplasma associated with Lethal Yellowing disease of oil palm, Coffee Crispiness, and Machorro of lulo (*Solanum quitoense*). The causal agents of these diseases were identified by DNA sequence analysis of the ITS region. Protocols to detect phytoplasma in oil palm, coffee and lulo were developed and DNA sequences reported in GenBank. For oil palm a protocol was also developed to identify phytoplasma by DNA sequence analysis of the 16S rRNA region obtained from insect vectors and weeds.
- Knowledge on an unreported *Phytophthora* specie in cassava in Colombia by DNA sequence analysis of the ITS region was reported in Gen Bank.
- The combined effect of hot water treatment of stem cuttings, biocontrol agents and selection of stem cuttings on Phytophthora Root Rot (PRR) under field conditions in Quindío increased yield of commercial roots by 4.5 t/ha (42.5%), compared with conventional farmer practices. From plots under farmer agronomic management, 8.5 t/ha of roots with rot was obtained, as against 6.9 t/ha (i.e., 18.8% less) from plots under ecological management. 36.8% of roots suffered from rot under traditional farmer management, whereas only 26.2% under integrated management based on ecological practices. Extensionists and farmers were

trained during an international workshop and field days at different regions in Colombia about strategies and practices to reduce PRR.

- Several companies in Colombia are commercializing successful biofungicides prepared from leaves of swinglea shrub (*Swinglea glutinosa*) based on results of research carried out by CIAT. Two producers of agrochemicals have interest in patenting a process to produce a liquid plantain compost extract. Both extracts control Powdery Mildew of rose caused by *Sphaerotheca pannosa*.
- Training of researchers, technicians and farmers from Latin America, Caribbean, Africa and Europe on the management of cassava, oil palm and plantain diseases and research technology by field days and meetings. Together with different partners a number of project proposals were prepared.

Rice Pathology

- Two blast pathotypes affecting highly resistant cultivars were detected and corresponding genes conferring resistance identified.
- A gene conferring wide spectrum of blast resistance and derived from a wild rice species was identified and used in breeding.
- Seventeen potential donors of stable rice blast resistance were identified.
- Thirty-three potential donors of rice sheath blight resistance were identified.
- Fourteen genetic groups were identified within rice sheath blight pathogen populations.

Bean Pathology

- We showed a lack of host differential interaction in the common bacterial blight / common bean pathosystem, and that the CBB pathogens might not have co-evolved with common bean gene pools.
- A molecular assay for specific detection and differentiation of CBB pathogens in bean seed, and the protocol for its application was developed.
- Studies showed that the population structure of *C. lindemuthianum* is changing, as evidenced by the resistance of previously susceptible varieties.
- Showed that the varieties Widusa, Kaboon (Andean) and G 2333 (Mesoamerican) can be used to effectively manage all anthracnose races found in Colombia.
- Three potential biocontrol agents for bean pathogens were identified and tentatively classified as *Paenibacillus polymyxa*, *Bacillus subtilis* and *Gluconobacter* spp.
- Showed that the antimicrobial compound is possibly protein in nature and one of the bacteria produces a heat resistant compound.
- Preliminary results showed *Calliandra calothyrsus*, as the best source of green manure.

Forage Pathology

- Fungal pathogens in beans and *Brachiaria* controlled in direct spray applications of an antifungal protein isolated from *Clitoria ternatea* seeds.
- A mutant strain was marked for resistance to rifampicin from the original bacterial strain isolated from *Brachiaria* CIAT 36062 and that tested positive for *nifH* gene sequences was introduced into *Brachiaria* CIAT 36061.

4. Problems Encountered and their Solutions

- The CIAT Library is threatening to cut back on subscriptions to scientific journals due to budget restriction. This will adversely affect research in IPDM as numerous related journals are on the elimination list. This problem will continue to be with us and needs to be solved, probably at management level.
- The security situation in Colombia has improved over the past year; as more zones of the country have become accessible we have been able to expand field research into these areas. However there are areas of limited travel and accessibility.
- The IPDM project was targeted very hard by the core budget cuts during 2004. The IPDM project is one of the lowest funded projects in CIAT and this year's cuts wiped out all operational funds and some personnel positions. Some funds were recovered through special projects.
- Our taxonomic expertise of white grubs was lost during the year and this hindered identification of specimens collected in target areas. Pending sufficient funding we will contract another taxonomist.
- We wanted to conduct on-farm experiments to test control techniques of the burrower bug. However, Erupcion, the organization of the asparagus farmers near Manizales ceased the support due to insufficient support by the local consultant. It seems that the problems are resolved and we will resume activities in November when the new seed is established.
- CIAT can obtain more impact by means of special projects in cassava if greater collaboration between the CIAT units exists. For example, farmers and donors can be visited jointly, with the objective to prepare proposals and carry out research with an integral approach.

5. List Technologies, Methods & Tools

- New strategy for control of burrower bug in cassava developed.
- New entomopathogenic nematode identified for control of burrow bug or other soil born arthropods identified.
- Improved rearing methods of *Galleria mellonella* developed in the laboratory.
- Specific primers for detection of phytoplasma associated to Frogskin Disease and oil palm, were designed.
- Protocols are available for the detection of phytoplasma in cassava, oil palm, coffee, lulo (*Solanum quitoense*), insects and weeds by molecular markers. It includes cloning and sequencing of DNA for the taxonomic identification of these microorganisms.
- Forty-five DNA fragments of phytoplasma (coffee, cassava, lulo, oil palm), *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* (soursop), *Sphaceloma manihoticola* and *Sphaceloma krugii* (cassava), *Ralstonia solanacearum* (egg plant, Indian shot, hot pepper, *Heliconia* sp., tobacco, tomato), *Phytophthora cinnamomi* (*Calathea* sp.), *Phytophthora cryptogea* (*Heliconia* sp.), *Phytophthora tropicalis*, *Phytophthora melonis*, *Phytophthora nicotianae* (cassava), *Phytophthora palmivora* (cacao), *Pythium chamaeophyon* (cassava) were submitted to GenBank database of the NCBI (National Center for Biotechnology Information).
- The combination of *Metarhizium anisopliae* (CIAT 224) and the systemic pesticide imidacloprid at sublethal dose against the burrower bug gave highly promising results in the greenhouse (mortality > 80%).
- A reliable greenhouse methodology for the screening of germplasm for rice sheath blight resistance was developed and implemented.

- La Mosca Blanca como Transmisora de Enfermedades Virales. (Field guide for Farmers and Extension Personnel). Tropical Whitefly IPM Project.
- Control Físico de Mosca Blanca (*Bemisia tabaci*) para el Manejo de Enfermedades Virales en Cultivos Hortícolas (Field Guide for Farmers and Extension Personnel). Tropical Whitefly IPM Project.
- Methodologies for rearing colonies of homopterans, potential vectors of cassava frog skin disease developed.
- Bacteria isolated from gut of new species of entomopathogenic nematode; possibly a new species.
- Protein isolated from *Jatropha gossypifolia* toxic to cassava mealybug (*P. herreni*).
- Proteins detected in cassava possibly involved in resistance to whiteflies.
- A taxonomic key for the Colembola group associated with transgenic (Bt) and non-transgenic cotton has been developed.
- Methodologies for rearing colonies of white grubs (Scarab beetles; e.g. *Phyllophaga menetesi*) developed.

Germplasm Distributed

Rice

- Rice lines with blast resistance genes distributed to partners.
- Cassava whitefly resistance variety Nataima-31, distributed to farmers in Colombia.

Beans Africa

Germplasm distributed for pest tolerance/yield performance testing and evaluation

- **Kenya:** EXL 52, EXL 55, BACO-5-1/4, BACO4-5/31, KAT B9, KAT B1, RWR 2385, RWR 2778, RWR 2981, RWR 2005, RWR 2121, RWR 2407, RWR 2024, G 19168, G 8047, MAC-27, ECAB-0539. (Farmers have adopted EXL 52 and the grain can be located at the village markets in Otondo-Kabondo area of Kisii site).
- **Northern Tanzania:** CC 794, G 8047, G 1106, G 19792, G 22501, G 23333, G 11746, PAD 3, BAT 125, IKI (SINON), MLM 49, MLM 127, ZPV 292, IZO 201297, BESH BESH, Rojo, SUA 90, R 6, R 143, R 179, R 129, Local (Kyeeri), ZAA 12, IKI (SINON), PAD 3, BAT 1251b, Lyamungo 85, Lyamungo 90, Selian 94, Selian 97, Jesca.
- **Southern Tanzania:** IKI (SINON), ZP 292, G 22501, G 19792, MLM 127, TM27J1J2, BILFA 4, BILFA 8, BILFA 16, CAL 143, BAT 125a, Kabanima, EAI 2525, MG 38, Urafiki, Kablanketi, Wanja, Sugar 131, Uyole 03, Uyole 84, Uyole 94, Uyole 96, Uyole 98.
- **Malawi:** Sugar 131.

Cassava

- The whitefly resistant cassava variety Nataima-31 has been distributed to farmers in several regions of Colombia.

Software

- Internet Database on subterranean pests maintained and expanded.
- Database on arthropod pests of CIAT commodity crops expanded to also include fruit crops and others.
- PE-1 project (IPDM) web page.

- Database for Tropical Whitefly IPM project being expanded to also include a section in Spanish.
- Distribution maps for *Pythium* species characterized in Kenya and Rwanda were developed.

Electronic Modules

- Socioeconomic Survey. El Salvador. Access. Tropical Whitefly IPM Project.
- Begomovirus Characterization DB. El Salvador/Mexico. Word Document. Tropical Whitefly IPM Project.
- Bemisia tabaci biotypes. El Salvador and Mexico DB. Word Document. Tropical Whitefly IPM Project.

Genetic Mechanisms Understood and Sources Identified

- Resistance to bean weevil (*Acanthoscelides obtectus*) identified in hybrids from *P. vulgaris* x *P. acutifolia*.
- *Pythium* isolates (134) from root rot affected areas in Kenya and Rwanda characterized by sequencing of its ITS-1 region.
- Resistance to whiteflies identified in Wild *Manihot* species.

Rural Development Methods

- Training of cassava farmers (and other crops) in recognizing signs and symptoms of white grub damage and presence and instruction in basic identification of white grub larvae (Quindío, Cauca, Colombia).
- Workshops and field days used to train farmers and extensionists in control of Phytophthora root rot in cassava (Colombia).
- In Uganda FFS (Farmer Field Schools) and FRG (Farmer Research Groups) members and participating partners are instrumental in training new farmers and helping in the formation of groups.
- FPR methodologies is spreading bean pest and disease management technologies to more than 19,000 bean farmers in six African countries.

6. Publications List

Refereed Journal Articles and Monographs

Published: 45

Accepted and Submitted: 34

Book Chapters

Published: 5

In Press: 25

Submitted: 3

Workshop and Conference Papers: 28

Presentations and Posters: 46

Extension Bulletins and Brochures: 17

7. Training List

Organizer	Place	Date	Participants	Received by	Service
CIAT-MADR	CIAT	12 Oct. 2004	28	Farmers, administrators	Management of Pests
CIAT	CIAT	1 Oct. 2004	1	Gustavo Córdoba	Biological control of plant pathogens
CIAT	CIAT	30 Sep. 2004	1	Manuel Valdivié	Management of cassava diseases
CIAT	CIAT	3 Sep. 2004	3		Progress on management of bacterial wilt (<i>moko</i>) of plantain
CIAT/Biotechnología	Vereda Alegrías Santander de Q.	25 Aug. 2004	70	Professionals, extensionists and farmers from Cauca-AMUC (Asoc. Municipal de Usuarios Campesinos del Cauca)	Conference and field day. MIP in whitefly and Cassava Frogskin (CFS).
ASCOLFI	CIAT	9-10 Aug. 2004	30	Researchers	Diagnosis of diseases caused by viruses and phytoplasms
BAYER Colombia	Cereté	5 Aug. 2004	197	Farmers, Technical Assistants	The B biotype in the Cauca valley
FENALCE SENA	Pitalito-Huila	30 July 2004	85	Farmers, Producers, and technicians bean	Workshop to train technicians and farmers on the agronomic management of snap and dry beans and integrated disease management
SOCOLEN	Bogotá	28 July 2004	275	Researchers, Technical Assistants, Professors, Students	Sampling Methods for Whitefly Control
CIAT	CIAT	26 July-6 Aug. 2004	1	Hernán Zapata	Isolation and conservation of pathogens and biocontrollers, inoculum preparation, and pathogenicity tests
CIAT	CIAT	22 July 2004	3	Visitors from the Colombian Association of Banana Growers (AUGURA) and CENIBANANO	Integrated management of diseases for plantain, cassava, and oil palm
CIAT	Pescador, Cauca	1 July 2004	6	Farmers	Diagnosis and management of cassava diseases
FENALCE	Bogotá	24-25 June 2004	110	Farmers, Producers, and technicians bean	Workshop to train technicians and farmers on the agronomic management of snap and dry beans and integrated disease management
ERUPCION-CIAT	Manizales, Caldas	June 15, 2004	20	Producers, traders and agronomists in asparagus	Field day with Erupcion, an association of asparagus producers. Presentation of the latest results of research on the control of burrower bug

Organizer	Place	Date	Participants	Received by	Service
CIAT	Montería, Córdoba	5 June 2004	350	Functionaries from National bodies, and Private enterprises at the release of new cassava varieties	Management of cassava diseases, with a presentation on the diagnosis and management of Frogskin Disease
FENALCE – SENA – Secretary of Agriculture	Ibagué, Tolima	4 June 2004	60	Farmers, Technical Assistants	Pests of Beans and Their Control
FENALCE SENA	Ibagué, Tolima	4 June 2004	65	Farmers, Producers, and technicians bean	Workshop to train technicians and farmers on the agronomic management of snap and dry beans and integrated disease management
CIAT	CIAT	4 June 2004	37	Students, University of Caldas	Cassava and plantain diseases
CIAT	SENA-Armenia, Quindío	2 June 2004	42	Farmers, producers, extensionists, agronomists	Workshop on IPM in Cassava in the Coffee-growing Region, with Emphasis on Soil Pests-Phase 2 – farmers learned to identify the most important white grub species
CLAYUCA	CIAT	31 May-12 Jun. 2004	40	Scientists, farmers, extensionists, administrators	Conference and field day (MIP on cassava whitefly) in an International Course about Modern Systems of Production, Processing and Utilization of Cassava
CIAT	CIAT	20 May 2004	15	Colombo–Japanese Association	Integrated management of diseases for cassava, plantain, palm, and flowers
CIAT	CIAT	18 May 2004		Dr. Octavio Vargas, Mitsui & Co., Ltd.	Natural products in disease management.
CIAT	Orito, Putumayo	16 May 2004	30	Farmers, functionaries from National bodies, and NGOs	Diagnosis and management of Frogskin Disease and other cassava diseases
Universidad Nacional (Medellin)	CIAT	13 May 2004	13	Agronomy Students	Cassava Pests and biological control
CIAT, COLPRA - Pradera	Pradera	5 May 2004	76	Farmers, members of COLPRA – Pradera	Whiteflies and their control (field day)
CIAT	Casanare	May 2004		Palmar del Oriente, Palmas de Casanare, Palmeras Santana with researchers from CENIPALMA	Discussion of progress in diagnosing and identifying the causal agent of lethal wilt of oil palm
Universidad Nacional Abierta y a Distancia-Pereira	CIAT	30 April 2004	18	Students	Integrated Pest Management in Cassava
Colegio Tomás Cripriano Mosquera	CIAT	27 April 2004	32	Students	Workshop on Integrated Management of Soil Pests, with Emphasis on Microbiological Control

Organizer	Place	Date	Participants	Received by	Service
Universidad de Antioquia	CIAT	16 April 2004	13	Students of the University's Biology Institute	Workshop on Integrated Management of Soil Pests, with Emphasis on Microbiological Control
CIAT	Caldono-Pescador, Cauca	6 April 2004	35	Farmers	Course on the management of soil pests and transfer of technology
CIAT	Palmira	10 April 2004	35	CIAT personnel, students, researchers	The B biotype in the Cauca valley
CIAT	CIAT	24 March 2004	1	Nicolás Cock, Ecoflora Ltda.	Integrated management of diseases through plant extracts
CIAT	CIAT	15-17 March 2004	1	Ana Claudia Gordillo	Diagnosis and identification of <i>Ralstonia solanacearum</i> in plantain, banana, soil, weeds, and water
CIAT	CIAT	15 March 2004	8	Okechukwu Eke-Okoro, Titus Alicai, Christopher Omongo, William Sserubombwe, Mayanne Apok, Steven Tumwesigye	Disease diagnosis, molecular characterization of pathogens, molecular markers associated with resistance to cassava diseases, management of cassava diseases
CIAT	CIAT	12 March 2004	12	Chemonics	Disease diagnosis and management for cassava, rubber, cacao, and vanilla
CIAT	CIAT	March 2004	2	Liliana Cadavid and Susana Mejia. Universidad del Valle, Cali	Isolation, detection and pathogenicity test of pathogens
CIAT	Pereira	29 Feb. 2004	18	Farmers and students	Disease diagnosis and management for cassava
CIAT-MADR	Pereira	26 Feb. 2004	28	Farmers, Producers, Administrators, and Cassava Processors	Integrated Pest Management in Cassava in the Coffee-growing Region
CLAYUCA	CIAT	20 Feb. 2004	2	Ernesto Espinosa and José Ventura from INIVIT-Cuba	Integrated Management of the Whitefly <i>Aleurotrachelus socialis</i> with Emphasis on Varietal Resistance
CIAT-Subterranean Pests Project	Quimbaya, Quindío	17 Feb. 2004	32	Farmers, Producers, Students, Administrators, and Cassava Processors	Workshop on IPM in Cassava in the Coffee-growing Region, with Emphasis on Soil Pests
Universidad de Medellín	CIAT	17 Feb. 2004	20	Students of Biological Control Course	Biological Control of Cassava Pests, Nematodes and Taxonomy of Parasitoids
CENICAÑA	CIAT	16-20 Feb. 2004	4	Luis A. Gómez, Germán Vargas (Cenicaña); María Marín (Fedepanela); Luis A. Hincapié (IcA, Risaralda)	Workshop on Bioecology and IPM of the Spittlebug
CIAT	CIAT	15 Feb. 2004	1	Natali Cortés	Applied biotechnology to detect and control phytopathogenic agents
CIAT	CIAT	10 Feb. 2004	2	José Ventura and Ernesto Espinoza	Disease detection and diagnosis in cassava

Organizer	Place	Date	Participants	Received by	Service
CIAT	CIAT	Feb. 2004	1	Lorena Escobar. Universidad Nacional de Colombia	Isolation of <i>Phytophthora</i> species from chili pepper
BAYER Colombia	Cali	29 Jan. 2004	110	Farmers, Technical Assistants	The B biotype in the Cauca valley
COLPRA-Pradera, CIAT	Pradera	16 Dec. 2003	25	Farmers, members of COLPRA – Pradera	The B biotype in the Cauca valley
Inst. Nal. de Investigaciones Forestales y Agropecuarias-Yucatán, Mexico	CIAT	1-2 Dec. 2003	1	Raúl Díaz	Training in whitefly identification and mounting of specimens
Universidad Nacional, Palmira	CIAT	1-30 Nov. 2003	1	Sergio Prieto, Visiting Researcher	Evaluation of the level of mortality and body weight gain of the cassava hornworm (<i>E. ello</i>)
INIAP-Experiment Station in Portoviejo, Ecuador	CIAT	10-14 Nov. 2003	3	Oswaldo Valarezo, Ernesto Cañarte, Bernardo Navarrete	Mite taxonomy, preparation and mounting of mite specimens
CIAT	CIAT	4 Nov. 2003	5	Chemonics	Diagnostic and disease management of cassava and plantain crops
PROINPA, Bolivia	CIAT	24 Oct. 2003	1	Oscar Barea, Coordinator of Integrated Crop Management	Whitefly taxonomy
CIAT	CIAT	23 Oct. 2003	1	Philipp Aerni	Disease diagnosis, molecular characterization of pathogens, molecular markers associated with resistance to cassava diseases, and management of cassava diseases
COLPRA-Pradera	CIAT – Palmira	17 Oct. 2003	25	Farmers, members of COLPRA – Pradera	The B biotype in the Cauca valley
ESPE (Escuela Superior Politécnica del Ejército) in Quito, Ecuador; CIAT	CIAT-IPDM Unit	17-19 Sep. 2003	3	ESPE (Escuela Superior Politécnica del Ejército) in Quito, Ecuador	Integrated management of the whitefly, the cassava hornworm, and entomopathogens and mites
CIAT	CIAT	27-28 Aug. 2003	1	Edwin Iquize, Visitor from Bolivia	Visit to the CIAT experiment station in Santander de Quilichao / Training in sampling techniques to analyze the incidence and population fluctuations of the spittlebug and soil arthropods

Africa-Beans

Pilot Site	Satellite Sites	Number of Farmers Reached with at least 1 Technology	Estimated Number of Farmers aware of Bean IPDM Message
Malawi (Dedza)	Kasungu	500	> 1000
Tanzania - Southern (Mbeya and Mbozi)	Mbeya, Mbozi, Iringa, Njombe, Chunya,	7000	>10000
Tanzania - Northern (Hai, Lushoto, Arumeru)	Babati, Rombo, Moshi,	8800	>31000
Kenya (Kisii, Kabondo)	Homabay, Gucha, Marani, Rachuonyo, Vihiga, Hamisi, Kakamega	2500	>3000
Uganda	Kabale, Bushenyi, Kisoro, Iganga		
DR Congo	Katana, Kavumu, Mudaka		
Rwanda	Runyinya		

Number of Interns Student in Practice: 1

Individualized Training Received by CIAT Personnel: 13

- Cornell University, Training in Use of Feromonas and Rx, Sep. 15-Nov. 20, 2003. Ithaca, NY, USA. Anuar Morales. (CIAT Human Resource Development Fund).
- CIAT, How to Design and Manage Successful Research Projects, 27-31 Oct. 2003. Cali. Arturo Carabalí (CIAT Human Resource Development Fund).
- Harmonia. Corporación para el Desarrollo de Insumos y Servicios Agroecológicos. Cerrito-Valle, 14 April, 2004. Carlos Julio Herrera, Elsa Liliana Melo, Carlos A. Ortega.
- XXXI Congreso Sociedad Colombiana de Entomología, SOCOLEN. Bogotá, 28-30 July 2004. Students and Professionals of Integrated Pest and Disease Management Unit.
- Sixth International Scientific Meeting of the Cassava Biotechnology Network-CBN. CIAT, Cali, 8-14 March 2004. Students and Professionals of Integrated Pest and Disease Management Unit IPM-Cassava Project.
- Course “Taxonomía de Coleopteros: Scarabaeidae de Importancia Agrícola (Coleoptera: Scarabaeidae “Pleurosticti).” Twenty Technicians, Students and Professionals of Integrated Pest and Disease Management Unit. 6-10 Sep. 2004. (Professor: Jhon César Neita Moreno, Universidad Nacional, Bogotá).
- Visiting Scholar in the Department of Entomology. Jairo Rodríguez, IPM Project. NYSAES, Cornell University, 15 Sep.-15 Dec., 2003.
- Workshop on Gene Flow Analysis and Environmental Biosafety. Jairo Rodríguez, IPM Project. CIAT, Cali, Colombia, 7-9 Oct. 2004.
- Course “Taxonomía de Coleopteros: Scarabaeidae de Importancia Agrícola (Coleoptera: Scarabaeidae “Pleurosticti).” Caludia, M. Ospina, Paola Soelo, Anyimilehidi Mazo, IPM Project. CIAT, Cali, Colombia, 6-10 Sep. 2004. (Professor: Jhon César Neita Moreno, Universidad Nacional, Bogotá).
- IV Curso de Educación Continuada Museo Entomológico UNAB. Sistemática y Ecología de Microartrópodos. Claudia M. Ospina, IPM Project. Universidad Nacional, Bogotá. 3-14 May 2004.

- Curso Bioecología y MIP del Salivazo. Jairo Rodríguez, IPM Project. CIAT, Palmira, Colombia, 16-20 February 2004.
- Bayer CropScience, Integrated Pest Management in Cotton. Jairo Rodríguez, IPM Project. Buga-Valle, 30 April 2004.
- CORPOICA, Palmira. CORPOAGRO – IV Encuentro de Actualización Agrícola. Seminario 9. Palmira, 4 Sept. 2004.

Number of Visiting Scientists: 1

Number of Farmers Trained: > 19,000 (See Training List Tables for details)

Number of Higher Degree Students Supervised

PhD: Completed: 1	In Progress: 0
M.Sc.: Completed: 2	In Progress: 9
B.Sc.: Completed: 5	In Progress: 9

8. Resource Mobilization List

Proposals funded in 2004

- Integrated Control of Subterranean Pests (BMZ). US\$200,000.
- Assessing the impact of biotechnology on diversity: effect of transgenic maize on non-target soil organisms, (Biotechnology and Biodiversity Interface). US\$ 99,360, Cornell, 2002-2005.
- Protocol for the Monitoring and resistance Development to de Bollgard® Technology in Colombia. US\$ 30,960, CoaCol, 2004-2005.
- Pyramiding of mutated genes contributing to crop quality and resistance to stress affecting quality. Donor: International Atomic Energy Agency (IAEA) for 15 countries and several crops. US\$ 750,000 - 5 years.
- Identification of insect vectors and alternative hosts of phytoplasmas causing cassava frogskin disease. Presented to USAID. Funds requested: US\$ 12,000 - 1 year.
- Desarrollo de estrategias de manejo de cuero de sapo y superalargamiento en yuca, mediante investigación participativa. Presented to Ministerio de Agricultura y Desarrollo de Colombia. Funds requested: US\$ 14,546 - 1 year.
- Combating Hidden Hunger in Latin America: Biofortified crops with improved Vitamina A, Essential Minerals and Quality Protein (English). Presented to CIDA. Funds requested: US\$ 122,880 - 6 years.
- Integrated management of whiteflies in the tropics, DFID, 2001 – 2004, US\$ 65,000.
- Biotechnological tools to improve beans, ABOS, 2001 – 2004, US\$ 15,000.
- Post-harvest losses in beans, ZIL, 2002 – 2004, US\$ 36,000.
- Sustainable integrated management of whiteflies through host resistance, NZAID, 1 year, US\$50,000.
- Reconocimiento de las principales especies - plagas asociadas al cultivo de Espárragos en el municipio de Cajibío - Departamento del Cauca, SENA, 1 year, US\$50,000.
- Understanding the mechanisms of plant resistance to whiteflies; USDA/USAID (USA), 1 year, US\$34,146.
- Whitefly Biocontrol-USAID Link Fund, USAID-University of Florida, 1 year, US\$24,000.
- Manejo integrado de la mosca blanca de la yuca (*Aleurotrachelus socialis* Bondar) y estudios de transmisión del agente causal de cuero de sapo con (*Scaphytopius marginelineatus*) y otros posibles vectores. MADR, 1 year, US\$14,546.

List of Proposals submitted in 2004

- MADR: ca. US\$250,000 for two years.
- IPMEuope: US\$30,500.
- La respuesta y recuperación de los artrópodos no-blanco del suelo frente al uso del algodón transgénico. US\$77,985, Colciencias, 2005-2006.

- Manejo integrado de la enfermedad del Moko en plátano. Presented to Ministerio de Agricultura y Desarrollo de Colombia. Funds requested: US\$37.469.
- 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. Presented to The generation challenge programme. Funds requested: US\$289.200 per year, for 3 years.
- Desarrollo de métodos rápidos de detección de *Ralstonia solanacearum*, agente causante de Moko de plátano, en plantas, malezas, agua y suelo. Presented to Asohfrucol. Funds requested: US\$47.235.
- Manejo Integrado de Enfermedades del Cultivo de Yuca. Presented to Ministerio de Agricultura y Desarrollo de Colombia and IICA. Funds requested: US\$77.700.
- Desarrollo de prácticas de manejo de Pudrición de Raíz de yuca mediante la detección molecular de *Phytophthora* en zonas semi áridas en Cuba y Colombia. Presented to Cassava Biotechnology Network for Latin America and the Caribbean (CBN-LAC). Funds requested: US\$10.000.
- Improving rural livelihoods in Rwanda: Promoting integrated crop, disease, and pest management (ICDPM) strategies for intensification and diversification of agricultural systems, Bilateral project for Belgium, Concept note, 3 years, (2005-2007), 3 million Euros.
- Iniciativa Peruana de Rhizobiología : Fijación biológica de nitrógeno para el establecimiento de sistemas agrícolas sustentables y el progreso de los pequeños productores del Perú, IDRC, Rejected, 5 years, CAN\$ 999 625.
- Promotion of integrated pest management strategies of major insect pests of Phaseolus beans in hillsides systems in eastern, central and southern Africa, UK£ 81550, DFID/PPP.
- WOTRO. Evaluation of *Amitus macgowni* and *Encarsia* sp as biological control agents of *Aleurotrachelus socialis* on cassava in Colombia. March 2005, 2 years, US\$60,000.
- Sustainable integrated management of whiteflies as pests and vectors of plant viruses in the tropics. Phase 3 - Network Strengthening, Pest and Disease Dynamics and IPM Component Research. DFID.
- Classical biological control of the coconut mite (*Aceria guerreronis*) in Sri Lanka, IFAD, 3-4 years, US\$100,000.
- Determinar la actividad biológica del extracto obtenido de *Crotalaria* sp. en el control de insectos del suelo asociados al cultivo de la yuca y establecimiento de su producción industrial. MADR, 3 years, US\$44,120.
- Desarrollo de un biocontrolador comercial para el control de mosca blanca en la yuca basado en el hongo entomopatógeno *Lecanicillium lecanii* (*Verticillium lecanii*). MADR, 3 years, US\$71,800.
- Producción a nivel industrial del biocontrolador baculovirus de *E. ello* para controlar el gusano cachón de yuca como plaga limitante en plantaciones de caucho industrial. MADR, 3 years, US\$121,060.
- Establecimiento de un programa de fertilización mineral-orgánicas en yuca. MADR, 3 years, US\$31,720.
- Desarrollo de un sistema promotor de enraizamiento para caucho apoyado en el uso del hongo (*Trichoderma harzianum*). MADR, 3 years, US\$31,720.
- Development of low-cost technologies for pyramiding useful genes from wild relatives of cassava into elite progenitors. “The Generation Challenge Programme,” 3 years, US\$894,906.

9. New Directions for 2005

Narrative description of major changes, additions, deletions

Most IPDM research at CIAT is dependent upon the vision, goals and objectives of CIAT’s mandate commodity projects. All IPDM project scientists are also members of these commodity projects, and in fact, receive most of their funding support from the commodity projects.

In recent years there has been a general shift in priorities to give more emphasis in soil borne problems, including plant pathogens and arthropod pests. This coincides with CIAT's overall strategy to place "Land Degradation" as a development challenge. It is planned that IPDM will be a strong participant in this project theme. We have been approached by TSBF to become more involved in soil pests and disease problems in Africa and other areas and this is being explored.

A second areas of emphasis is in the identification, development and use of biological or botanical pesticides for both arthropod and plant disease control. Several IPDM scientists are now actively engaged in this type of research and these activities will continue to increase in the near future (3 to 5 years). On this theme we will probably become more involved in the formulation of biopesticides through joint agreements with commercial enterprises, as well as quality control evaluations licensed by ICA.

The pest problems on the major commodity crops have not changed dramatically over recent years. However some of the methods employed to study and evaluate these pests have become more sophisticated, especially in the use of molecular techniques and this trend will continue into the future. The role of genetically modified crops is already influencing our research direction. Projects related to Bt cassava, maize and cotton are in progress. The use of wild crop related species for identifying novel genes for control of arthropod pests and diseases will be encouraged, especially if special project funding can be secured to support this research. This type of research will also increase the need for innovative molecular techniques.

Since we are involved with dynamic systems, change is an expected occurrence. New pest species have moved into the region, including two whitefly species (cassava) a mite species (rice) and a mealybug species that could threaten CIAT crops, such as tropical fruits, is on our doorstep. These issues will have to be addressed in the future. In addition, biotypes of arthropod pests and new races of diseases or new viruses are a constant threat and require vigilance to detect changes in these organisms.

CIAT's expansion into tropical fruits opens a vast arena for participation of IPDM scientists. We already have some expertise in this area and our involvement could easily expand in the future. Initially emphasis will probably be on diagnostics and characterization and eventually into management systems.

It is not anticipated that the present balance between basic and applied research will shift in the near future. Success in IPM implementation requires the strong and continued support from basic research and the need to develop technologies to address the changes that occur at the farm production level.

Plans for next year

- Focus on the rice sheath blight pathogen (genetic resistance and identification of molecular markers, pathogen characterization).
- Evaluate wild relatives of *Manihot esculenta* (cassava) for pyramiding useful genes for resistance to cassava pests.
- Initiate studies on efficacy of whitefly parasitoids on cassava whiteflies.

- Continue research into the identification of possible vectors of Cassava Frogskin Disease.
- New control strategies for *C. bergi* (cassava burrower bug) combining entomopathogens and sub-lethal doses of pesticides, implemented in the field.
- Pathogenicity studies of entomopathogenic fungi and nematodes, on selected white grub species.
- Effects of intercropped plants as botanical control agents (e.g. *Tephrosia candida*, *Galactia striata*) on white grubs and burrower bugs described.
- Farmer participatory research methods employed to test, evaluate and adapt biological control technologies for control of soil pests of cassava and other crops in Colombia (in collaboration with NGO's and CORPOICA).
- Evaluate the effects of Bt cotton on lepidopteran pests.
- Research on the development of molecular markers for pod weevil, thrips, and bruchids to facilitate resistance breeding.
- Evaluations of *Brachiaria* hybrids for spittlebug resistance.
- Further characterization of CFSV, and screening for resistance.
- Continued pathology research in non-CIAT mandate crops, such as oil palm, banana, potato, vegetables, etc.
- Further research on detecting and identifying phytoplasma associated with CFSD.
- Research on cassava root rot pathogens will continue.
- Endophytes as gene delivery systems evaluated in endophyte-*Brachiaria* interactions.
- Evaluation of Andean and Mesoamerican wild bean accessions with spectrum of common bacterial blight pathogens.
- Identification and characterization of bacteria as potential biocontrol bacterial agents.
- Evaluation of green manures for beneficial microorganisms for the control of root rot pathogens in beans.

PROJECT PE-1: INTEGRATED PEST AND DISEASE MANAGEMENT

1. 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:

6. Pest and disease complexes described and analyzed.
7. Pest and disease management components and IPM strategies and tactics developed.
8. NARS' capacity to design and execute IPM research and implementation strengthened.
9. 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:

2005 Botanical and other traditional pesticides or control practices in beans evaluated by farmers.

Entomology

Cassava whitefly natural enemies identified.

Homopteran species (2) collected and reared and vector transmission studies initiated for cassava frog skin disease.

Complexes of soil borne pests associated with cassava identified in Colombia.

Entomopathogens for control of selected soil borne cassava pests identified (for white grubs and burrower bugs).

One hundred new *Brachiaria* hybrids with multiple resistance to spittlebug available.

Molecular markers for Mexican bean weevil (*Zabrotes subfasciatus*) resistance available in common bean.

Bean stem maggot tolerant bean varieties evaluated in farmers fields in Kenya, Malawi and Tanzania.

Pathology

Role of endophytic fungi in plant protection of forages defined and biocidal proteins of plant origin characterized. I

Identification of sources of different known rice blast resistance genes and microsatellite markers.

Identification of rice lines with tolerance to sheath blight pathogen and development of genetic crosses.

Quantification using bioassay method for bean *Fusarium* root rot pathogen in soil.

Pythium root rot pathogens on beans in Eastern Africa characterized and distribution established.

Common bean genotypes with resistance to angular leaf spot, *Phaeoisariopsis griseola* identified.

Identification of rice blast resistance genes present in 200 Latin America rice cultivars.

Candidate genes for resistance to CBB and *Phytophthora* Root Rot of cassava identified.

Novel approaches in scaling up bean IPDM technologies evaluated in Eastern and Central Africa.

Virology

Molecular marker for one resistant gene to rice hoja blanca virus available.

Cassava frog skin disease resistance identified.

2006 Participatory IPM practices for control of cassava soil borne pests evaluated at pilot sites in Colombia.

Genetic studies of sheath blight resistance in rice and identification of molecular markers associated with resistance.

Entomology

Biological pesticides identified for whitefly (*A. socialis*) control on cassava and evaluated whitefly predators and parasitoids released and evaluated in farmers fields.

At least two commercial *Brachiaria* cultivars with multiple resistance to spittlebug developed.

Molecular markers for bean pod weevil derived from crosses between Mesoamerican *Phaseolus vulgaris* genotypes available.

Botanical and other traditional pesticides for bean pest management evaluated by farmers in Eastern and Southern Africa.

Pathology

Inheritance of anthracnose (*Colletotrichum lindemuthianum*) resistance in Andean bean germplasm identified and elucidated.

Bacterial endophytes isolated from *Brachiaria* antifungal protein isolated from seeds of tropical forage legume.

Micro satellite markers associated with rice blast resistant genes (Pi-1, Pi-2, Pi-33, Pi-K, Pi-b, Pi-ta and Pi-ta2) identified and distributed to Latin America Rice Program.

Isolates of *Trichoderma*, a soil associated fungus; with beneficial characteristics identified for *Phytophthora* Root Rot (PRR) control in cassava.

Quantification molecular assay method for bean *Pythium* root rot pathogens in soil validated in Uganda under field conditions.

Selection of rice blast resistant lines advanced from crosses between Latin American rice cultivars and donors of complementary resistance genes.

Virology

Additional characterization of the Reo-like virus associated with CFSD.

Developing capacity for diagnosis of citrus viruses.

2007 Biological pesticides for cassava soil borne arthropod pests developed (for burrower bugs and specified white grub species).

Brachiaria hybrids resistant to *Rhizoctonia* foliar blight developed.

Incorporation of genes conferring stable rice blast resistance using molecular markers assisted selection into rice breeding populations.

Development of rice breeding population incorporating genes conferring tolerance to the sheath blight pathogen through marker assisted selection

Biological pesticide for Moko or Banana Bacterial Wilt (*Ralstonia solanacearum* available).

Bioassay and molecular assay methods for bean *Pythium* and *Fusarium* root rot pathogens in soil validated.

Angular leaf spot and *Pythium* root rot resistance genes characterized and deployed in improved varieties in beans in Eastern, Central and Southern Africa.

Cassava whitefly (*A. socialis*) IPM technologies implemented in farmers fields using FPR practices.

IPM of soil borne cassava arthropod pests implemented on cassava and possibly other crops.

Whitefly IPM implemented with common bean farmers in Colombia and Ecuador.

Novel approaches in scaling up bean integrated pest and disease management technologies evaluated in Eastern and Southern Africa.

Farmer Participatory Research and technology development implemented in common bean production in Eastern and Southern Africa.

Pathology

Co-evolution of the anthracnose (*Collectotrichum lindemuthianum*) pathogen and common bean gene pools characterized.

Gene for antifungal protein cloned from tropical forage clitoria and characterized for use in transgenic plants.

Identification of resistance sources of phytoplasma associated with Cassava Frog Skin Disease (CFSD) using molecular markers.

Virology

Using resistance for Cassava frog skin disease more effectively.

Mild strain of Citrus tristeza virus tested for use as a cross protection agent.

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, Biocaribe); 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 Plant Health in the Systemwide program on IPM.

CIAT: PE-1 Project Log Frame (2005-2007)

Project: Integrated Pest and Disease Management

Project Manager: Anthony Bellotti

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
<p>Goal To increase crop yields and reduce environmental contamination through the effective management of major pests and diseases.</p>	<p>Increased crop yields. Reductions in environmental degradation through adoption of improved technology. Reduction of losses to several major diseases.</p>	<p><u>Production statistics.</u> Adoption and impact studies. Project reports.</p>	
<p>Purpose To develop and transfer knowledge systems and pest-and-disease management components for sustainable productivity and healthier environments.</p>	<p>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.</p>	<p>End-of-project reports. Refereed publications, book chapters. Adoption and impact studies.</p>	<p>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.</p>
<p>Output 1 Pest and disease complexes described and analyzed.</p>	<p>2005 Reduction in cassava whitefly damage. Colonies of homopteran (1 or 2) species established. Biology determined (1species). Transmission studies carried out. Taxonomic identification of white grub and burrower bug species. Experimental data available. Detection of endophytic fungi in <i>Brachiaria</i> and distribution determined. A set of microsatellite markers associated with blast resistance genes.</p>	<p><u>All areas: project reports, refereed publications, book chapters.</u> 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.</p>	<p>NARS have the needed resources. Adequate interaction with other disciplinary scientists. <u>Successful experiments.</u> 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.</p>
	<p>A set of 20 rice lines with tolerance to sheath blight identified. Isolates of <i>Fusarium</i> and <i>Pythium</i> pathogens in beans characterized and identified to species. Physical marker available, documented by publication in the annual report and a journal paper. 2006 AFLP fingerprints for <i>C. lindemuthianum</i></p>		

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	<p>generated. Experimental data available. Antifungal activity indicated on test fungus (<i>Rhizoctonia solani</i>) in <i>Brachiaria</i>. Practices to control <i>Phytophthora</i> Root Rot (PRR) validated by selected Colombian cassava farmers. Isolates of <i>Pythium</i> pathogens on beans characterized and identified. Data available for publication. Better diagnostic method and more information on the virus published in the annual report and journal paper. Diagnostic tools for citrus psorosis virus and citrus leprosis virus developed and available for certification programs.</p> <p>2007 RAMS and AFLP data for <i>C. lindemuthiauuanum</i> available. Antifungal protein gene identified and available in tropical forages. DNA sequences in gene bank for resistance to cassava frog skin disease reported and published.</p>		
<p>Output 2 Pest-and-disease management components and IPM strategies and tactics developed.</p>	<p>2005 Taxonomic identification Entomopathogenic fungi or bacteria or nematodes; data from laboratory experiments available. Publications in journals. Analysis of field and greenhouse data. Levels of resistance confirmed in bean progenies. Five to ten tolerant bean varieties selected in farmers' fields and greenhouse evaluation. Experimental data available; resistant bean lines identified. Set of rice blast isolates with a virulence genes for corresponding resistance genes. DNA sequences in cassava gene bank reported.</p> <p>Extension service providers (50), and farmers (300) trained in Bean IPDM in Uganda and Rwanda. A list of sources of CFSD resistance will be available. The work published in the annual report and a journal paper.</p>	<p>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.</p>	<p>Funding for research and technology (IPM) practices available. Stakeholders are willing to participate.</p>

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	<p>2006</p> <p>Agreement with commercial biopesticide industry established for product development.</p> <p>Two commercial <i>Brachiaria</i> cultivars with spittlebug resistance available to farmers.</p> <p>Levels of resistance confirmed in bean genotypes</p> <p>500 common bean farmers in Malawi, 1500 in Kenya and 8000 in Tanzania evaluated botanical biopesticides and other pest management options.</p> <p>Distribution of rice nurseries with 50 potential donors of blast and sheath blight resistance to Latin American countries.</p> <p>2007</p> <p>Three to four biological pesticides commercially available for farmers.</p> <p>Foliar blight resistant <i>Brachiaria</i> hybrids available.</p> <p>Multiplication and distribution of Latin American rice cultivars with complementary blast resistance genes incorporated.</p> <p>Implementation of marker assisted selection breeding program for sheath blight resistance in rice.</p> <p>Practices to control Moko of banana validated by selected banana farmers in Colombia.</p> <p>Research partners in Kenya and Rwanda trained and collaborate in <i>Pythium</i> root rot assays on beans.</p> <p>Angular leaf spot and <i>Pythium</i> resistant bean varieties available to Bean Farmers.</p> <p>The populations for genetic studies develop and F2 population analyzed for disease susceptibility and molecular markers.</p> <p>Results of study using several CTV mild strains to determine if they provide adequate protection.</p>		

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
<p>Output 3 NARS' capacity to design and execute IPM research and implementation strengthened.</p>	<p>2005 Five hundred farmers in Malawi, 1500 in Kenya, 8000 in Tanzania and 1000 in Uganda evaluated biopesticide and other pest management practices on common bean crop.</p> <p>2006 Cassava, maize and onion farmers trained in management of soil borne pests (white grubs and burrowers bugs). Molecular markers associated with resistance identified in rice.</p>	<p>Reports on training courses. Concept notes and projects prepared with partners. IPM projects implemented</p>	<p>Trainees are keen to become trainers of farmer communities.</p>
	<p>2007 Combination of whitefly resistant cassava varieties and biological control agents available to farmers and farmers trained. Application of biopesticides and cultural practices by farmers. Hundred or more bean farmers and technicians trained in whitefly management. Combination of pest resistant bean varieties and biological control agents available to farmers and farmers trained. Awareness of IPM in beans created among policy makers and other stake holders (NGO's, private sector, schools, etc.). Farmers meetings, field days, exchange visits, publication of promotional material.</p>		
<p>Output 4 Global IPM networks and knowledge systems developed.</p>	<p>Network of researchers established. Preparation of Web pages and databases with relevant IPM information.</p>	<p>Electronically published Web pages and databases. Progress reports.</p>	