Phase III - Year Two: 2005-2006

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Women selling vegetables in a market in India
Naidu Rayapati
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Integrated Pest Management Collaborative Research Support Program FY 2006 Annual Report

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Table of Contents

EXECUTIVE SUMMARY 1

INTRODUCTION 5

PHASE III LONG-TERM RESEARCH PROGRAMS 7

IPM in Latin America and the Caribbean: Crops for Broad-based Growth and Perennial Production for Fragile Ecosystems 8
Regional IPM Program for East Africa: Kenya, Tanzania and Uganda 13
Regional Integrated Pest Management Research and Education for South Asia 18
Ecologically-Based Participatory IPM for Southeast Asia 25
Ecologically-Based Participatory and Collaborative Research and Capacity Building in IPM in the Central Asia Region 33
West Africa IPM Center of Excellence 38
Integrated Pest Management of Specialty Crops In Eastern Europe 41
Management of the Weed Parthenium (Parthenium hysterophorus L.) in Eastern and Southern Africa Using Integrated Cultural and Biological Measures 43
Regional Diagnostic Laboratories 52
Integrated Management of Thrips-Borne Tospoviruses in Vegetable Cropping Systems 55
Collaborative Assessment and Management of Insect-Transmitted Viruses 61
Applications of Information Technology and Databases in IPM in Developing Countries and Development of a Global IPM Technology Database 65
IPM Impact Assessment for the IPM CRSP 67

TECHNOLOGY TRANSFER PROGRAMS 69

Technology Transfer Activities in Mali 70
Technology Transfer in Central America – Guatemala and Honduras 74
Technology Transfer in the Caribbean 75
GIS Implementation and Training in the Caribbean 77
Technology Transfer in the Philippines 79
Technology Transfer – Bangladesh 82
Technology Transfer in Albania 88
Technology Transfer of IPM Training and Capacity Building 91
Development of an Online Reporting System for IPM CRSP 92

TRAINING AND CAPACITY BUILDING 93

Training and Institutional Capacity Development 94
IPM CRSP Degree Training Participants (Graduate students): FY 2006 96
IPM CRSP Degree Training Participants (Bachelor's Degree Students): FY 2006 99
IPM CRSP Non-Degree Training, FY 2006 100
IPM CRSP Non-Degree Training (Summary), FY 2006 107
IPM CRSP Publications, Presentations, and other Products, FY 2006 108
Publications and Other Products of the IPM CRSP Compilation for the Year FY 2006 (Summary) 120

APPENDICES 121

Appendix A -List of Acronyms 122
Appendix B - Collaborating Institutions 124

EXECUTIVE SUMMARY

The Integrated Pest Management Collaborative Research Support Program (IPM CRSP) is an initiative of USAID. It is a collaborative partnership among U.S. and host country institutions with an emphasis on research, education, training, and information exchange. The concept of IPM has been evolving for the past five decades and the Virginia Tech has been implementing the IPM CRSP project for the past 13 years (Phases I, II and III) with continuous support from USAID. It has brought together investigators from 22 US Universities and nine International Agricultural Research Institutes and scientists from over 30 countries comprising seven regions, and five continents for the participatory IPM.

The objectives of the IPM CRSP program are: a) advance IPM science, and develop IPM technologies, information, and systems for sound land resource management; b) improve IPM communication and education, and the ability of beneficial practitioners to manage knowledge, resulting in widespread adaptation, adoption, and impact of ecologically-based IPM technologies, practices and systems; c) provide information and capacity building to reform and strengthen policies and local/national institutions that influence pest management; and d) develop and integrate sustainable resource-based local enterprises into national, regional, and global markets.

This program is designed to develop and implement a replicable approach to IPM that will help reduce: a) agricultural losses due to pests; b) damage to natural ecosystems including loss of biodiversity; and c) pollution and contamination of food and water supplies. It combines strong regional IPM programs with work on critical global cross-cutting themes.

The objective of this report is to present the technical progress made in the Phase III Long-Term Research Program and the Technology Transfer activities of the bridging Phase I and II with Phase III of the IPM CRSP.

Long-term Research Program: The Long-Term Research Activities (Phase III) were awarded in August 2005 after external Review Panel (ERP) selection and ranking. In the FY 2006, the IPM CRSP established the Long-Term Research Programs that will generate the core of new participatory Integrated Pest Management (IPM) knowledge and development impacts. The following seven Regional Programs and six Global Theme Programs were awarded.

Regional Programs:

IPM in Latin America and the Caribbean: Crops for broad-based growth and perennial production for fragile ecosystems. Lead PI, Jeffrey Alwang, Virginia Tech; Partners: Purdue, Penn State, Florida A&M, Ohio State, UC-Davis, and Arizona; Host Countries: Honduras, Ecuador, Dominican Republic, and Trinidad and Tobago.

Regional IPM program in East Africa. Lead PI: Mark Erbaugh, Ohio State; Partners: Virginia Tech, Tennessee State, Texas A&M, and Wisconsin; Host Countries: Kenya, Tanzania, and Uganda.

Regional Integrated Pest Management Research and Education for South Asia. Lead PI: Edwin Rajotte, Penn State; Partners: Ohio State, and Virginia Tech; Host Countries: Bangladesh, Nepal, and India.

Ecologically-based Participatory IPM for Southeast Asia. Lead PI: Michael Hammig, Clemson; Partners: Washington State, Kansas State, Oregon State, and NC A&T; Host Countries: Indonesia, and Philippines.

Ecologically-based Participatory and Collaborative Research and Capacity Building in IPM in the Central Asia region. Lead PI: Karim Maredia, Michigan State; Partners: UC-Davis; Host Countries: Tajikistan, Uzbekistan, and Kyrgyzstan.

West African Consortium of IPM Excellence. PI: Don Mullins, Virginia Tech; Partners: Fort Valley State, Purdue, Ohio State, and UC-Davis; Host Countries: Mali, Burkina Faso, The Gambia, Guinea, and Senegal.

Integrated Pest Management of Specialty Crops in Eastern Europe. PI: Doug Pfeiffer; Virginia Tech; Partners: Ohio State, and UC Davis; Host Countries: Albania, Moldova, and Ukraine.

Global Theme Programs:

Management of the Weed Parthenium. Lead PI: Wondi Mersie, Virginia State; Partners: Virginia Tech; Host Countries: Ethiopia, Uganda, Botswana, Swaziland, and South Africa.

Regional Diagnostic Laboratories. Lead PI: Sally Miller, Ohio State; Partners: U. Florida, Virginia Tech, U. Wisconsin, UC-Davis; Host Countries: Benin, Tanzania, and Guatemala.

Integrated Management of Thrips-Borne Tospoviruses in Vegetable Cropping Systems in South Asia. Lead PI: Naidu Rayapati, Washington State; Partners: Georgia; USDA-ARS-USHRL; Host Country: India.

Collaborative Assessment and Management of Insect-Transmitted Viruses. Lead PI: Sue Tolin, Virginia Tech; Partners: Ohio State, Arizona, UC-Davis, Georgia; Partners: Guatemala, Honduras, Dominican Republic, Jamaica, Mali, Burkino Faso, and Cameroon.

Application of Information Technology and Databases in IPM in Developing Countries and Development of a Global IPM Technology Database. Lead PI: Yulu Xia, North Carolina State; Partners: Penn State, Virginia Tech, Purdue, and Clemson; Host Countries: All regions of IPM CRSP.

IPM Impact Assessment for the IPM CRSP. Lead PI: George Norton, Virginia Tech; Partner: Minnesota; Host Countries: All regions of IPM CRSP

Technology Transfer Programs

To bridge activities of the past 12 years of IPM CRSP with the new Phase III program, the following Technology Transfer projects were awarded.

West Africa Site in Mali: Larry Vaughan, Virginia Tech (Site Chair); Kadiatou Toure Gamby, IER (Site Research Coordinator); Bourema Dembele, IER (Site Administrative Coordinator).

East Africa Site in Uganda: Mark Erbaugh, Ohio State University (Site Chair); Sam Kyamanywa, Makerere University (Site Coordinator); George Bigirwa, NARO (Deputy Site Coordinator).

South America Site in Ecuador: Jeff Alwang, Virginia Tech, (Site Chair), Carmen Suarez INIAP (Site Coordinator); Victor Brrera, INIAP (Vice Site Coordinator).

Central America sites in Guatemala and Honduras: Steve Weller, Purdue University, (Site Chair); Luis Calderon, ICADA, Guatemala (Site Chair)

Caribbean Site in Jamaica: Sue Tolin, Virginia Tech (Site Chair); Dionne Clarke-Harris, CARDI (Site Coordinator)

Southeast Asia Site in the Philippines: Sally Miller, Ohio state University (Site Chair); Herminia Rapusas, PhilRice (Site Coordinator).

Southeast Asia Site in Indonesia: Mike Hammig, (Site Chair) and Merle Shepard, Clemson University.

Southeast Site in Bangladesh: Ed Rajotte, Pennsylvania State University (Site Chair); Rezaul Karim, Horticulture Research Center, BARI (Site Coordinator)

Eastern Europe Site in Albania: Doug Pfeiffer, Virginia Tech (Site Chair); Joef Tedeschini, Crop Protection Institute, Durres (Site Coordinator).

Michigan State University: Karim Maredia

North Carolina State University: Ron Stinner

Program Impact Areas:

IPM CRSP FY 2006 activities in have produced the following outputs:

Long-Term Projects

- 42 - Long-term degree students (28 men and 14 women)
- 1219- Short-term training participants
- 20 – Workshops
- 17 – Meetings
- 9 – Training sessions
- 2 – Radio programs
- 1 – Field day
- 1 - Seminar
- 17 - Refereed journal articles
- 6 - Non-refereed articles
- 6 - Book chapters
- 5 - Articles in proceedings
- 75 - presentations in workshops and conferences
- 8 - websites developed
- 2 - Manuals
- 7 - Brochures
- 1 - Poster
- 2 - Annual reports

Technology Transfer Projects:

- 8201 - Short-term training participants
- 21 - Workshops
- 33 – Training sessions
- 1 – Farmers field school
- 1 - Meeting
- 9 - Non-refereed publications

- 13 - Presentations in workshops and conferences
- 2 - Manuals
- 2 - Brochures
- 10 - Fact sheets
- 3 - Posters
- 4 - Videos
- 3 - Media releases
- 8 - Feature and news articles

Training and Institutional Development: IPM CRSP Research Activities contributed to short and long term training. Forty two students from 17 countries were involved in long term degree training. Of these 37 were from developing countries and five were from the U.S. There were 28 men and 14 women students who were working on 18 Ph.D., 19 M.S. and 5 B.S. degree programs. Graduate students were majoring in Agricultural Economics (12), Crop Science/ Crop Protection (5), Entomology (5), Horticulture (4), Plant Breeding (1), Plant Biotechnology (1), Plant Science (2), Plant Pathology (6), and Plant Virology (1). Twenty students were enrolled in six U.S. Universities and 17 were studying in the developing country institutions. It also supported five undergraduate students.

IPM CRSP supported 100 short term training activities involving over 9,420 persons representing about 40 different countries. There were 88 scientific presentations and about 3960 persons attended

INTRODUCTION

The FY 2006 Annual Report for the year two of IPM CRSP phase III describes activities from October 1, 2005 through September 30 2006 under Leader-with-Associate Agreement No. EPP-A-00-04-00016-00 between the United States Agency for International Development and the Office for International Research, Education, and Development at Virginia Polytechnic Institute and State University.

The IPM CRSP is a collaborative partnership among U.S. and host country institutions with an emphasis on research, education, training and information exchange. This program was conceptualized by USAID to address health, environment, and economic issues globally through IPM interventions. It consists of a consortium of IPM disciplines from U. S. Universities working collaboratively to reduce 1) agricultural losses due to pests; 2) damage to national ecosystems; and 3) pollution and contamination of food and water supplies.

The goals of the CRSP are to develop improved IPM technologies and institutional changes that will increase farmer income, reduce pesticide use and pesticide residues on domestic and export products, improve IPM research and education program capabilities, improve ability to monitor pests, and increase the involvement of women in IPM decision making and program design. By reaching these goals, the results of the IPM CRSP program will directly contribute to the strategic objective of the Land Resource Management Team (LRMT) of Economic Growth, Agriculture and Trade/ Natural Resource Management (EGAT/NRM) to increase the capacity of USAID and its partners to advance land resource benefits. Additional information on the IPM CRSP is provided in the website; http://www.oired.vt.edu/ipmcrsp/.

This report highlights the activities of the IPM CRSP Year 2 of the Leader with Associate Agreement No. EPP-A-00-04-00016-00. The first part of the report presents the highlights of the competitively awarded Long-Term Research Regional programs: Latin America and the Caribbean, East Africa, South Asia, Southeast Asia, Central Asia, West Africa, and Eastern Europe; and Long-Term Research Global Theme programs: Management of the Weed Parthenium, Regional Diagnostic Laboratories, Management of Thrips-Borne Tospoviruses, Management of Insect-Transmitted Viruses, Application of Information Technology and Databases in IPM, and IPM Impact assessment.

The second section of the report contains highlights of Year 2 activities of non-competitively awarded Technology Transfer projects. It includes technology transfer activities involving the partners or the Phase II IPM CRSP on a regional basis: East Africa (Uganda), West Africa (Mali), Caribbean (Guatemala and Honduras), Eastern Europe (Albania), and South Asia (Bangladesh and Philippines). In addition, the technology transfer activities of new IPM partners, Clemson University (Philippines), Michigan State University and North Carolina State University are detailed in this report. The reports of technology transfer projects awarded to University of California – Davis, and Florida A&M University have been incorporated in the reports of West Africa Regional program and Latin America and Caribbean program, respectively. Consortium for Crop Protection (CICP) ceased to exist in the middle of the first year of this project.

The third section contains training and institutional capacity development activities including long-term and short-term trainings. The fourth section is an appendix of tables compiled on graduate students supported, non-degree trainings offered, and other details.

PHASE III LONG-TERM RESEARCH PROGRAMS

IPM in Latin America and the Caribbean: Crops for Broad-based Growth and Perennial Production for Fragile Ecosystems

Jeffrey Alwang, Virginia Tech

The Collaborative Program

Collaborators: Stephen Weller, Purdue University; Sue Tolin, Virginia Tech; and Paul Backman; Penn State University,

Partners: 1.Florida A&M University; 2. Ohio State University; 3. Instituto Nacional Autónomo de Investigaciones Agropecuarias (Ecuador); 4. Instituto Dominicano de Investigaciones Agropecuarias y Forestales (Dominican Republic); 5. Centro para el Desarrollo Agropecuario y Forestal (Dominican Republic); 6. USDA/ARS Sustainable Perennial Crops Laboratory, Beltsville, MD; 7. USDA/ARS Vegetable Crops Laboratory, Charleston, SC; 8. CARDI – Caribbean Agricultural Research and Development Institute; 9. CAB International (Trinidad and Costa Rica); 10. University of the West Indies; 11. FHIA – Honduran Foundation for Agricultural Research; 12. Zamarano – School of Tropical Agriculture, Honduras; 13. ICADA – Instituto Centroamericano de Desarrollo Agropecuario; 14. World Cocoa Foundation; 15. INIBAP; and 16. AVRDC – The World Vegetable Center.

The regional IPM program for Latin America and the Caribbean (LAC) addresses pest management issues for selected seasonal and perennial crops. LAC includes heterogeneous island, coastal, and mountainous ecosystems with highly diverse human societies. In these settings, seasonal crops contribute to income and exports, help reduce poverty and food insecurity, and provide engines of growth for lagging regions. In addition, perennials can bring economic stability to areas with fragile ecosystems, reduce soil erosion and deforestation, and contribute to biodiversity conservation. Because perennials and seasonal crops are often produced in association, they face complex pest problems that need to be addressed in an integrated fashion. The LAC regional program focuses on solanaceous, cucurbits, diversified highland vegetables, cacao, and plantain in Central America (Honduras), South America (Ecuador), and the Caribbean (Dominican Republic, and to a lesser extent, Trinidad and Tobago and smaller islands). It involves a comprehensive participatory approach that builds on past successes, is multi-disciplinary, and improves environmental quality through reduced pesticide use and biodiversity monitoring.

The project capitalizes on prior IPM CRSP work in the region by advancing transfer of developed IPM technologies and continuing to build human capacity. IPM in LAC can dramatically influence agricultural trade, allow proactive monitoring of invasive species, and their migration potential into the neighboring U.S. Our activities help protect LAC agriculture and benefit U.S. farmers through transferable pest management techniques and consumers by ensuring a continuous and safe food supply.

IPM Constraints Addressed

Main constraints for seasonal, perennial and mixed-cropping systems include:

(i) identify and quantify factors influencing pest problems in mixed cropping systems (e.g., plantain-cacao, and others) using participatory methods;
(ii) adapt and transfer ecologically based IPM knowledge and devise IPM solutions;
(iii) test these on farmer fields; and
(iv) promote outreach and dissemination. Cacao, a new focus for the IPM CRSP, faces witch's broom, frosty pod and *Phytophthora* diseases as major problems, which can cause greater than 50% losses.

Additional constraints addressed by the regional project include:

(i) The best means of transferring farmer-friendly IPM technologies be efficiently developed and transferred;
(ii) Use of IPM branding and better marketing to increase profitability;
(iii) The relationship between pest management and environmental quality, biodiversity and social sustainability;
(iv) Means of increasing regional export of IPM crops given growing phytosanitary market barriers;
(v) Effective means of controlling spread of invasive species with minimal distorting impacts on international trade; and

(vi) Use of IPM-based knowledge to help build sustainable economies and communities in remote areas.

Research Achievements

Development of an early test to evaluate cacao resistance to frosty pod and witches´ broom

Two methods of plant propogation are being developed and/or refined in collaboration with Dr. Carmen Suarez of the Pichilingue INIAP station. There have been several communications to improve efficiency of cacao tissue culture (callus production) and to improve the regeneration of plants from callus. These techniques are developing well, and appear to be producing clonal plants of superior cacao lines that are suitable for out-planting. The rooted cutting method of producing clonal plants has been a little more problematic. The ability to efficiently root plants is driven by a finely tuned mixture of plant hormones that can vary between plant lines. Arrangements were made to transfer frosty pod isolates to Penn State under their APHIS/PPQ permit to develop prototype systems for screening of lines for sensitivity to frosty pod.

Evaluation of many cacao lines for witches broom susceptibility was already underway, by placing small plants under trees heavily infested with witches broom. It was obvious that this method was demonstrating differences in sensitivities to the fungal pathogen responsible for the disease. Additional time is needed to analyze the data and determine if results are repeatable and valid. Protocols for rapid screening of Frosty pod remain to be developed.

Assessment of pathogens in cacao/plantain-producing areas

Travel in Manabi province indicated that cacao in this northern area was afflicted with witches' broom, frosty pod and black pod rot. These observations were similar to those made in Guayas, Los Rios, Bolivar, and Cotopaxi provinces. The frosty pod and witches' broom were less severe in the foothill districts of Cotopaxi and Bolivar provinces. Black pod seemed more severe in the foothill areas. In all areas, closely planted spacings of cacao were more heavily infested with frosty pod and witches' broom. The effect of interplanting cacao with plantain was unclear as to the effects of cacao diseases. For plantain, the crops were typically infected with black sigatoka disease. Unexpectedly, the disease levels were sometimes more severe on hill tops, indicating a potential role for nutrient insufficiency (such as potassium) in this environment. Also in the Northern region of Ecuador there was severe damage to plantain cause by black weevils boring into the lower part of the banana's pseudostem (trunk), often weakening the plant so that it would fall over. The severity of this problem justifies an entomologist's input into the overall project.

An experiment had been designed for planting on the Pichilingue station that would evaluate cacao and plantain intercropping densities for effects on cacao and plantain diseases. After consultations with Dr Alwang, the plans were modified, and the trees were planted on a 10 ha plot of land in March 2006. The severity of all diseases will be monitored for at least the next 10 years. This is a major experiment for INIAP personnel (Suarez and Vera), and should provide critical data on diseases of both crops.

IPM collaborator in plantain producing area.

Refinement of Fusarium control techniques in naranjilla-growing areas of Ecuador

Efficiency of fungicides recommended for late blight control in Ecuador: Ridomil Gold, Fitoraz 76 and Kemicar was evaluated for control of late blight in the naranjilla variety Nanegalito grafted on the rootstock ECU-6242 of *Solanum hirtum*. This accession is resistant to *Fusarium oxysporum* and

Meloydogyne incognita. Ridomil gold was the most effective fungicide for control of late blight on naranjilla. Fitoraz was also effective and the rotation of Fitoras with Ridomil Gold is a good strategy to aid in preventing fungicide resistance development to both metalaxil and cymoxanil. The most promising cultivar found in Nanegalito-Pichincha (Nanegalito) was used for making line selections. In this study, variation in fruit pulp color and taste test was evident, demonstrating the cross pollination nature of naranjilla. Selection of the most promising genotypes within these naranjilla populations is being conducted in order to obtain a more productive and uniform line to be eventually released as a new variety. With these new developments, we now have a promising variety, which can be grafted onto a root stock with resistance to *M incognita* and *F. oxysporum*. In addition, the technology to control late blight and fruit borer is also available. These strategies will, in the short term, allow cultivation of "common naranjilla", which was in the past extremely difficult or only partially successful in primary and secondary forests. In this study, we have also selected lines from crosses within the section *Lasiocarpa* resistant to *F. oxysporum*. These lines will also be evaluated for resistance to *P. infestans* and *M. ingognita*.

IPM package for mixed cultivation in plantain, Ecuador

IPM in cacao/plantain must make a switch to IPM practices by its small land holders. Assessments made earlier showed that pruning of diseased plant parts, plant spacing and intercropping densities were all important in maintaining productivity and economic sustainability. In addition, it was also beneficial to plant on sloping land (foothill locations) and certainly to use superior varieties. Often, many of the large landholders are already utilizing many of these strategies. Work is continuing to understand the individual contributions, and combined effects of these strategies through observations, and controlled experiments. We have also made a collection of cacao endophytes (60+ isolates) which are presently being screened for beneficial effects in suppressing cacao diseases. In preliminary tests, some of these can live in the leaf for the duration of the leaf's life, and can suppress black rot in treated leaves and nearby non-treated leaves. Since these are Ecuadorian isolates, it could lead to a small industry that would market their native microflora.

Identification of key pest complexes in Honduras

A preliminary list was developed of the important local vegetable crops and their field and post-harvest phytosanitary problems by general groups of pests, .i.e., viruses, fungi, insects, nematodes. A survey form is being developed for distribution among pertinent parties to specifically pin-point and prioritize within each crop identified the particular pests that, according to those parties, might merit particular research efforts.

Soil solarization techniques for management of soil borne pests in vegetable crops

Two replicated validation trials were established on May/2006, one to evaluate solarization for the treatment of seedbeds used for production of onion transplants at FHIA's Experimental and Demonstration Center for Horticulture (CEDEH, Departamento of Comayagua), and the other to evaluate its effect on nursery substrate mixes at Santa Catarina Experimental and Demonstration Station at La Esperanza (FHIA-LAE, Intibuca). The treatments under validation were solarization for 6 weeks using either single and double layer of transparent plastic (3 mil), in comparison to chemical treatment (Basamid®) sealed with plastic, and an Untreated control. Data produced in both studies are being analyzed. The collection of bibliographic information and pictures for eventual production of a grower-friendly illustrated brochure and a PowerPoint presentation was completed.

Use of transplants produced in anti-insect screen houses in production of crops

Reconnaissance trips were made to the highlands of La Esperanza (Intibuca) and Marcala (La Paz), Southwestern Honduras, to evaluate the different types of structures currently used by small growers in those areas and to identify candidate places where the structures might be built. Based on functionality of the design, costs, and ease of construction, the model promoted by World Vision was chosen as the most appropriate structure. Construction information, including design, costs and the sites with the best potential to build the structures, have been defined. Also, information concerning to production of seedlings under protected structures is being acquired to eventually produce the manual for growers.

Disinfestation treatment of strawberry planting material with hot water for control of the Cyclamen mite

A trial field was established at FHIA-LAE during week 4, 2006, in which the performance of planting material (crowns) that had been dipped for 30 minutes in water heated at 43°C was compared to that of crowns treated by dipping them in acaricide solution (0.1% Endosulfan in water, the current grower's practice) and to an Untreated control. A single 400 m² plot was planted for each treatment. Plots were weekly scouted for mites and other pests, following a systematic sampling scheme (3 x 5 m grid). The thermally-treated planting material was free from Cyclamen mites (*Phytonemus pallidus*) for 26 weeks, while the other two plots had populations that required weekly acaricide treatment since plant emergence until the end of the trial. The total and marketable yield of the thermally treated plants was significantly higher than the other two treatments. The cost of production using thermally-treated planting material was considerably less, since it did not require the application of acaricide throughout the season. The report is in the process of completion.

Management of the Cyclamen mite in strawberry

A field trial was established at FHIA-LAE on week 6, 2006 to determine the efficacy of the predatory mite *Neoseilus californicus* to reduce the populations of the Cyclamen mite, *P. pallidus* in strawberries, in comparison the current grower's practice (weekly acaricide applications throughout the season). The treatments were applied to single 300 m² plots. Two weeks after the beginning of the rainy season, strawberry beds were covered with plastic tunnels to protect plants from the rain. Mite population and other pests were scouted weekly, following a systematic sampling scheme (3 x 5 m grid). The effect of predators on *P. pallidus* population was first observed two weeks after the release, when a significant difference in population between the two plots was detected. Predators kept the phytophagous mites under check during the rainy season. During the time plants were exposed to the rain, the population of both mites was reduced drastically. After the tunnels were placed, the *P. pallidus* population recovered but not the predatory mites. Total and marketable yield were similar for both treatments. The report is in the process of completion.

Management of the Broad mite in Chinese eggplant

A field trial was initiated at CEDEH (Comayagua) on week 2, 2006 to study the ability of the predatory mite *N. californicus* to survive, become established and control the populations of the broad mite, *Polyphagotarsonemus latus*, in Chinese eggplant, when used in combination with the use of compatible pesticides, in comparison to the current grower's practice of use of synthetic pesticides. Each treatment was applied in two plots totaling, approximately, 2100 m². Phytophagous and predatory mite populations and other pests were scouted weekly following a systematic sampling scheme (4.5 x 5 m grid). Mites were released on February 22 and March 31, but did not become established. In a preliminary trial conducted in 2005, *N. californicus* released on April 22, became established and were able to lower the broad mite population to undetectable level. Analysis of climatic conditions posterior to the release of the predators indicate that the predators released in 2006 may have been affected by low relative humidity which, on the average, was 18 percent points lower than in the 2005 season.

Management of the Thrips tabaci-Alternaria porri complex in onions in Honduras

Effect of the orientation, number and type of nozzle of the spraying equipment used for the control of *Thrips tabaci* in onions with pesticides. The study was established on March 22, 2006 at CEDEH (Comayagua). Factors evaluated were nozzle type (flat or hollow cone), number and orientation of nozzles (one aiming downwards, or two aiming forward and backwards, respectively), use of single-nozzle lance or multi-nozzle spraying boom, and pressure variation (40 or 60 psi). Parameters recorded in the study included yield (qualitative and quantitative), thrips control (number of thrips per leaf), time and volume required for application each treatment, and coverage/deposition tests using fluorescent dyes and water sensitive paper. Data produced in the study were analyzed and the report is being prepared. The best results pest- and yield-wise were obtained using a spraying boom fitted with four hollow cone nozzles aiming downwards at 40 psi.

Release of Minute Pirate bug, *Orius insidiosus*, for the management of onion thrips, *Thrips tabaci*, in an onion-cowpea system. A preliminary trial to observe the capability of the Minute Pirate bug to become established, reproduce and control onion thrips in an enhanced environment. Two arrangements of onion-cowpea (3:1 and 6:1 beds) were compared to continuous onion beds. Onions and cowpea were planted on week 7, 2006. Predatory bugs were released on week 14, at a rate of 1 bug/m². Thrips and predator populations were monitored weekly. Scouting after predator release did not detect their presence neither on onions nor cowpea. The trial was terminated after two weeks with no detection of predators and hard pesticides were sprayed to control the rising thrips population.

Monitoring populations of onion thrips, *Thrips tabaci*, with white sticky traps. A preliminary trial to establish the methodology was conducted at CEDEH. White cards of 150 cm² (10.7 x 14 cm) covered with a sticky paste (Tangle-Trap®) were placed in an onion plot. After exposure for one week, traps were collected and taken to the laboratory for examination with a stereoscope to count the number of trapped thrips. Upon collection, the cards were covered with plastic wrap, which allowed for handling and counting without smearing the sticky paste around. The readings at the laboratory showed that thrips had positively been captured in the traps. During the coming season a formal field trial will be set up evaluating the white sticky traps *versus* direct counts in plants as a means of monitoring thrips populations for early decision-making in threshold-based insecticide applications schemes.

Effect of mycorrhizal fungi on growth, yield and disease occurrence on tomato, bell pepper and cucumber

One replicated experiment of each tomato, bell pepper and cucumber was established at CEDEH (Comayagua) to evaluate the effect of the products Trichozam (*Trichoderma* sp., 250 g/ha, Zamorano) and Mycoral (*Glomus* sp., 25 g/plant, Zamorano), in comparison to a commercial chemical control treatment [1.25 l/ha of Previcur (Propyl 3-(dimethylamino) propilcarbamate) + 500 ml/ha of Derosal (methylbenzimidazol-2-carbamate)] applied as a drench at the time of transplanting, and to an Untreated control. The full dosages of treatments 3 and 4 were splitted 50 % to the substrate at the time of seed sowing in the trays and 50 % ten days after transplant. Field work started on June 1st and finished and September 27. Soil, crop, insect and airborne disease management were done according to guidelines for commercial production in Honduras. Data on root and airborne diseases incidence and severity was recorded in the field and root samples are being analyzed in FHIA's Plant Pathology Laboratory to determine de identity of plant pathogens colonizing the roots. Data on plant growth, yield and root colonization by *Trichoderma* and *Glomus* has been taken and is being processed.

Technology Transfer

Socioeconomic and information-diffusion methods in naranjilla-growing areas of Ecuador

- Steve Buck finished thesis and presented papers in two professional meetings and several University seminars and will be submitted for publication this year.
- Paper on socioeconomics in Naranjilla-growing area has been completed.
- An MS program in IPM has been started at the University of Santo Domingo, with 33 participants.
- At the Instituto Superior de Agricultura (ISA) in Santiago an addition 25 students entered the MS program in plant protection.
- Both these programs were supported by the IPM CRSP.
- South-south technology transfer will begin in subsequent years of the project.

Field training in IPM.

Workshop on IPM package for mixed cultivation in plantain, Ecuador

A workshop on identification of families, subfamilies and tribes of economically important insect groups in western Ecuador was conducted. The workshop was held June 12-16 at E.E.T. Pichilingue, and attracted 25 participants. Most were from INIAP stations in Boliche, Santo Domingo, and Manabí but two were from the Galapagos, and one from Santa Catalina.

Impact Assessment

Monitoring impact of alternative IPM programs in Honduras

Between 6 to 12/October Dr. Sarah Hamilton (U. of Denver, Colorado) made a tour with J. Mauricio Rivera C. visiting potential sites in Honduras for the development of the impact study and meeting/contacting potential collaborators, including local USAID officers, staff at Zamorano University, social scientists, growers, government officers, others. In addition, links were made with Dr. J. Sell (U. of Arizona) who is responsible of a similar study in the context of the IPM CRSP global theme on "Insect-Transmitted Virus Diseases of Vegetable Crops", with the idea of combining both activities as one common study

Regional IPM Program for East Africa: Kenya, Tanzania and Uganda

Mark Erbaugh, Ohio State University

The Collaborative Program

The Regional IPM Program for East Africa (RP/EA) focuses on Uganda, Kenya, and Tanzania. The two main complementary objectives are to develop a regional model of collaborative IPM research and training, and to disseminate knowledge that focuses on improving the productivity of higher-value marketed horticultural crops. These objectives and the administrative structure of the RP/EA were designed and agreed upon at the IPM CRSP Strategic Planning meeting held in Nairobi in 2005. The regional program is administered by a Coordinating Unit (CU) headquartered at Makerere University Faculty of Agriculture (MU/FA) and led by the Regional Coordinator (RC), Dr. Samuel Kyamanywa. The RC works closely with RP/EA Site Chair, Dr. Mark Erbaugh to guide the development of the program. The CU is advised by the Regional Technical Committee (RTC) which is composed of one person from each country, the Regional Coordinator, the Site Chairperson and regional and U.S.-based technical experts as available. RTC members are also responsible for administering and supervising IPM CRSP research activities in their respective countries. The RTC members are Dr. Mary Wabule, Kenya Agricultural Research Institute (KARI), Dr. Amon Maerere, Sokoine University of Agriculture (SUA), Dr. Samuel Kyamanywa, MU/FA, and Dr. Mark Erbaugh, The Ohio State University. The RTC has met twice over the past year in Nairobi, Kenya, in March and September of 2006.

The IPM CRSP RP/EA research effort is collaborating with several other regional agricultural research organizations, projects, and IPM CRSP thematic programs. These organizations include: MU/FA, and the National Agricultural Research Organization (NARO) that includes the Coffee Research Institute (CORI) from Uganda; KARI and Egerton University from Kenya; and SUA and the Tanzania Coffee Research Institute (TACRI) from Tanzania. The regional program is also cooperating with the World Vegetable Center (AVRDC), the International Center for Insect Physiology and Ecology (ICIPE), and the Agricultural Production Enhancement Project (APEP). U.S.-based co-PIs are from The Ohio State University and Virginia Tech. The activities of the International Plant Diagnostic Network (IPDN) and the Impact Assessment Global Theme are also being integrated into RP/EA activities. Additionally, RTC members including Dr. A. P. Maerere and Professor K.P. Sibuga, together with the Site Chair, Mark Erbaugh, the Regional Program Coordinator, Prof. S. Kyamanywa and the Kenyan PI Mrs. Mary Wabule, visited collaborating institutions in Arusha, Tanzania including the Asian Vegetable Research Center – East Africa Region and the TACRI, from September 26th to 28th of 2006.

Subcontracts have been established with the three cooperating countries and AVRDC. Research activities have also been initiated in all three countries on priority crops. All three countries are focusing research attention on tomato, which was ranked as the most important horticultural crop by an ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa) survey and at the Strategic Planning meeting. Uganda and Tanzania have implemented baseline surveys with Arabica coffee growers, and Uganda has initiated biological monitoring activities with growers on Mt. Elgon. Uganda and Kenya are cooperating on developing strategies to reduce important pest and disease constraints on passion fruit. The IPDN is cooperating with the RP/EA to develop appropriate and efficient diagnostic tools for banana bacterial wilt. Special investigations of *Helicoverpa armigera* that will use GIS and GPS tools and integrated vegetable trials have also been designed. USAID missions in all three countries have been informed of our activities; however, mission turnover in two countries has required renewed communications.

IPM Constraints Addressed

The Strategic Planning Meeting held in Nairobi, Kenya in 2005 with key stakeholders from the region identified and prioritized two main constraints on IPM development and dissemination as being: lack of regional coordination and shared strategy, and lack of an IPM research focus on higher-value horticultural crops. These two problem areas along with crop and pest priorities (pests being insects, diseases and weeds) were also identified at this same meeting and are detailed below.

Lack of Regional Coordination/Shared Strategy has hindered knowledge generation and flows across borders and resulted in undue research fragmentation. The challenge is to develop a shared strategy for regionalization that simultaneously addresses key technical and programmatic considerations, allocates research tasks, and facilitates research networking and knowledge sharing among stakeholders.

Lack of an IPM Research Focus on Higher-Value Horticultural Crops has led to an increased need for IPM research and grower training programs. The importance of IPM research for horticultural production in EA is widely recognized. Participants at the recent *Global Horticultural Assessment* in Arusha, Tanzania ranked IPM among the top priorities, cutting across all issues of horticultural production in the region. They also ranked pests and diseases as the second most important production constraint. Horticultural production was also identified and ranked most highly by participants at the Strategic Planning meeting in Nairobi, and is consistent with USAID's Agricultural Strategy titled, *Linking Producers to Markets* (2004). USAID mission strategic objectives in all three countries emphasize the need to increase production of horticultural and other higher value crops as a way to spur agriculturally-led economic development**.** Priority insect pests and diseases by crop follow**.**

IPM tomato field demonstration.

***Tomatoes*.** The tomato was ranked as the most important horticultural crop in all three participating nations in the ASARECA Survey and at the Strategic Planning meeting. Tomatoes are grown predominantly by small scale producers for both home consumption and domestic markets. They represent an important cash crop for small-scale growers and are associated with increased rural incomes, living standards, nutrition, and employment. They are one of the most internationally traded horticultural commodities in the region. Tomato production is limited in the region by a plethora of pests and diseases. The most important tomato pest problems in the region are late blight *(Phytophthora infestans)*, bacterial wilt *(Ralstonia solanacearum)*, bollworm (*Helicoverpa armigera*) and thrips *(Thrips tabaci* and *Frankliniella sp.)*. Other important pests that have been identified are Tomato yellow leaf curl virus and Cucumber mosaic virus, Cotton aphid (*Aphis gossypii*), whitefly (*Bemisia argentifolii* and *B. tabaci*), broad mite (*Polyphagotarsonemus latus*) and red spider mite (*Tetranychus* spp).

Bananas. Bananas and plantains are important staple crops in all three countries in the region. Banana production in Uganda and the region is now threatened by a new destructive disease, banana xanthomonas wilt (BXW) *Xanthomonas campestris* pv. *musacearum*, which is spreading rapidly in Uganda and threatening neighboring countries. In response to this threat, USAID/REDSO proposes to use FY 2005 Famine Funds to put into place a strategy to cope with the emerging BXW pandemic. For this reason, it will be important to ascertain the level of pathogen diversity in *X. campestris* pv. *musacearum* in order to efficiently and effectively develop disease-resistant banana varieties.

Coffee (*Coffea Arabica)*. Coffee remains the single most important cash crop in EA. It is primarily cultivated and produced by small-scale holders and contributes jobs to the labor market, primarily those associated with processing, transportation and marketing. Coffee therefore significantly contributes to poverty reduction, economic growth and general improvement of the livelihood of the people in the region. However, tremendous challenges face the coffee industry in Uganda, ranging from problems of low productivity to fluctuating world market prices. Low productivity is attributable to lack of improved technologies, rudimentary crop husbandry practices, and insect pests and diseases. Insect pests and diseases collectively account for a loss of over 50% in yields of Arabica coffee in Uganda. Total yield losses have been recorded on many farms. Major insect pests of Arabica coffee are antestia bugs (*Antestiopsis* spp), coffee lace bugs (*Habrochila* spp.), coffee stem borers (*Bixadus seirricola* White), coffee root mealybugs (*Planococcus ireneus* De Lotto), leaf miners (*Leucoptera* spp.) and the common coffee mealybug (*Planococcus kenaye* Le Pelley). The major diseases of Arabica coffee are coffee leaf rust (*Hemileia vastatrix* Berk & Br) and coffee berry disease (*Colletotrichum coffeanum* Noack). Of lesser importance are brown eye-spot (*Cercospora coffeicola* Berk. & Cke), fusarium die-back (*Fusarium stilboides* Wollenw.), Elgon die-back (*Pseudomonas syringae*), ascochyta die-back (*Phoma tarda*) and root rot (*Armillaria melea* Vahl).

Passion Fruit (*Passiflora edulis* Sims). Passion fruit has been identified as one of eight fruits for export promotion in the region by the Common Market for Eastern and Southern Africa (COMESA). It is largely produced by smallholders. Thus, the reduction of production constraints has the potential to significantly contribute to increases in rural income. Major biological constraints include insect pests scales (*Aonidiella aurantii*), aphids (*Aphis gossypii, Myzus persicae)*, mealy bug (*Planococcus kenya*), and nematodes (*Meloideogyne* spp). Important diseases are Brown spot (*Alternaria passiflorae),* Fusarium wilt (*Fusarium oxysporum f.sp. passiflorae*), and viral diseases, including Passionfruit woodiness potyvirus (PWV) and passiflora latent carlavirus (PLV), spread by aphids (*Aphis gossypii, Myzus persicae*)**.**

Scotch bonnet pepper. Major pests of Scotch bonnet pepper in Mpigi district were identified as fruitflies (*Dacus* spp.), whitefly (*Bemisia tabaci*), thrips, (*Frankliniella* sp.), bollworm (*Helicoverpa armigera*) and mites. Most of the above identified pests are polyphagous, therefore, their management is difficult without knowledge of integrated pest management principles. The major diseases observed include Anthracnose (caused by *Colletotricum* spp.), viruses and *Cercospora.*

Establishment of a Regional IPM Program Organization

The Regional IPM program for East Africa was launched and formalized with the selection of Dr. Kyamanywa as the Regional Coordinator at the first meeting of the RTC in Nairobi, Kenya on March 2-4, 2006. The RTC includes representatives from each of three participating regional institutions and the Site Chair as well as other regional and U.S.-based Co-PIs as available. Four Subcontracts were established by February 27, 2006, with three regional institutions, including the Makerere University Faculty of Agriculture, the Kenya Agricultural Research Institute, and Sokoine University of Agriculture. An additional subcontract was signed with AVRDC. An RP/EA website portal was created by Dr. Dan Taylor of Virginia Tech at:http://www.aaec.vt.edu/ipmcrspuganda/IPMCRSPEA.

Two meetings of the RTC were held: a workshop on planning and coordinating socioeconomic and biological baseline monitoring in Morogoro, Tanzania,and a visit to the collaborating research organizations of AVRDC and TACRI, near Arusha, Tanzania. The first meeting of the RTC was held in Nairobi, Kenya, on March 2-4, 2006, with Drs. Wabule (KARI), Maerere (SUA), Mumera (Egerton), Kyamanywa (Regional Coordinator and Makerere), Dan Taylor (VT) and Erbaugh (OSU and Site Chair).

Two socioeconomic baseline training programs were held, and both were led by Drs. Erbaugh and Taylor. The first was held on April 26-27 in Mbale, Uganda for eight coffee extension agents and two APEP field advisors to collaboratively develop an instrument and sampling methodology for coffee growers on Mt. Elgon, Uganda. A second training was held at SUA in Morogoro, Tanzania on May 2-3, 2006 and focused on developing a shared methodology for socioeconomic baseline surveys in Tanzania (tomato and coffee) and Kenya (tomato). The following socioeconomic baseline studies have been implemented: Coffee, Uganda, June 10, 2006; Tomato, Kenya, completed by July 15, 2006; Tomato, Tanzania, completed by August 30, 2006; Coffee, Tanzania, completed by October 20, 2006. Biological baseline monitoring training for Tanzania and Kenya was held at SUA on May 2-3, 2006. It was led by Drs. Kovach and Kyamanywa. New biological baselines that have been undertaken are the following:

- Coffee, Uganda, began implementation on June 15, 2006
- Kenya and Tanzania, initiated September, 2006

Research Accomplishments

IPM research programs for high value marketed horticultural crops

The decision was made by the RTC to shift research from cabbage to hot and sweet peppers; it was also decided that reporting for this and subsequent years will reflect this alteration.

In Uganda, data collection on pest/disease incidence and yield loss assessment for the on-farm trials continues. Results indicate the main pests and diseases are: Fruitflies (*Dacus* spp.), whitefly (*Bemisia tabaci*), thrips, (*Frankliniella* sp.), and bollworm (*Helicoverpa armigera*) and mites. Important diseases include a complex of viral disease, anthracnose (caused by *Colletotricum* spp. and *Cercospora*. Fruit fly damage was the most outstanding cause of un-marketable fruits.

At AVRDC/Arusha, an experiment at the nursery stage will be laid out in an RCBD design with three replications. Lines will be evaluated for resistance to diseases (soilborne, foliar and fruit diseases) and insect pests. An additional experiment at

AVRDC/Arusha will evaluate marigold for management of insect pest populations. This will be an experiment (RCBD with three replications) planted with marigold (1 row) followed by sweet/hot (depending on the highest germination rate) pepper (6 rows of 6 m long) and repeated twice. This will be compared to pepper in monocrop. Each plot is bordered by maize (2 m), and the bare ground is also planted with maize (3 m). The experimental plot is 52 m long and 35 m wide. It is expected that the insect pests will colonize the marigolds more and be less established on the pepper plants.

Biologically-based interventions for managing *Helicoverpa armigera*

Sampling was initiated this year and will be continued next year at research locations in four Ugandan districts (Wakiso, Masaka, Kayonga and Mbale). Ten tomato farms will be sampled in each district. Location and elevation will be obtained from the GPS unit. Each farm will be sampled twice during the season, i.e. during flowering and fruiting. *H. armigera* will be sampled on all alternate host plants within a 100m radius of our focal tomato field. In addition, other tomato fields within a 100m radius of the focal tomato field will be sampled. Parasitoids will be sampled by collecting bollworm larvae of various instars and rearing them out. Common predatory species will be sampled. Information will be obtained from the farmer about all pesticide use for the season up to that point. All other plant species (that are at a significant density) within a 100m radius of the focal tomato field will be recorded. This includes intercrops and other vegetation within the focal tomato field. Tomato variety and planting date will also be noted. Soil type, land use, precipitation and other data may be obtained from other sources, depending on budget limitations.

GIS data layers are being assembled with assistance from GIS contacts in Africa and the United States. ArcView 3.2 software is being reinstalled on computers at Makerere, and ArcGIS 9.1 software will be purchased for subsequent work. Sample locations collected with GPS receivers will be loaded into the preliminary GIS in Uganda and also transferred to Virginia Tech for processing. All GIS data, both collected as part of the bollworm project and GIS baselayers, will be integrated into the first version of the bollworm GIS in Uganda.

Integrated disease management strategy for passion fruit in the region

Characterization of local germplasm in Uganda:
To characterize germplasm, 60 accessions from 15 districts of Uganda were planted at Kawanda Agricultural Research Institute, both under field and screen house conditions in a two single-replicate completely randomized block design. Data were collected on morphological and growth traits. Molecular characterization was carried out using simple sequence repeats (SSRs) with eight polymorphic primer pairs developed for yellow passion fruit. Randomly amplified polymorphic DNAs (RAPDs) with four primers were also used. Result: 4 SSR primers have been identified for characterizing germplasm.

Screening for host tolerance to viral diseases in Uganda

Germplasm screening for resistance against viruses was conducted through a graft inoculation method. Six accessions were tested. Data was taken on disease severity and viral titre using enzyme-linked immunosorbent assay (ELISA) with *potyvirus* antiserum. Results: A *potyvirus* with biological similarity to passion fruit ring-spot virus has been identified in Uganda and its partial capsid protein (CP) gene sequenced. Preliminary results indicate tolerance in at least 2 yellow passion fruit types.

Survey of passion fruit varieties and viruses in Kenya:

The passion fruit survey was carried out in collaboration with the German Technical Cooperation (GTZ) team through visits to production areas and collecting samples for identification. The survey was carried out by a multidisciplinary team of scientists and extension officers. The most common diseases/pests were fusarium wilt, woodiness virus, brown spot and thrips. Given the complexity of the diseases, further identification and characterization of the pathogens will be carried out to ascertain the viral or fungal strains affecting passion fruit and to develop appropriate control methods.

Biotechnology tools for studying bacterial wilt and evaluating banana cultivars for resistance to the disease

More than 120 isolates of *Xanthomonas campestris* pv. *musacearum* from Uganda and Rwanda have been assembled by Makerere University and IITA Uganda. These have been shipped to The Ohio State University (S. Miller lab) for use in the development of diagnostic assays.

To characterize the pathogen, over 120 isolates from diverse areas in Uganda were screened using restriction fragment length polymorphism (RFLP) analysis of a section of the *Hrp* gene and random amplified polymorphic DNA (RAPD) analysis of total genomic DNA. Based on RFLP analysis with enzymes *Rsa* 1 and *Hae* III and RAPD analysis, no diversity was observed in the population of Xcm in Uganda. Further analysis of more than 40 Xcm strains from several East African countries by repPCR also demonstrated a very low level of variation among strains.

A PCR assay was developed based on the Hrp gene and tested against more than 30 strains of Xcm. The assay is highly specific for Xcm, detecting all Xcm strains and no strains of other Xanthomonas pathovars or other bacteria. The PCR assay is currently being tested at Makerere University with plant samples.

Two monoclonal antibodies generally specific for *Xanthomonas* spp., developed by Dr. Anne Alvarez (University of Hawaii) and currently under license with Agdia, Inc. (of Elkhart, Indiana, USA), have been obtained for evaluation. The specificity of the antibodies will be evaluated next year and if acceptable will be further tested in East Africa.

Two isolates of *Xanthomonas campestris* pv.*musacearum* (XCM) and 19 bacterial species isolated from banana tissues, soil and nectar were employed in developing a selective medium for the banana bacterial wilt pathogen. The medium was based on the capacity of Xcm to grow on the basal medium and also to tolerate a range of antibiotics to which other contaminating bacterial species were sensitive. Seventeen antibiotics, selected because of their previous use in suppressing related bacteria were tested for their ability to suppress these species. These were incorporated into a basal medium that was previously screened. A medium based on the antibiotics cephalexin and 5-fluorouracil proved the best. In comparison with the previously used medium, the newly formulated medium improved the selectivity of Xcm by about 50%. This medium is undergoing further tests and improvements, and is tentatively code-named CCA.

Major highlights:

- A new selective medium for Xcm has beenformulated, and it is now routinely used to isolate the bacteria from a diverse array of sources including birds, insects and nectar, with high levels of success.
- The population of Xcm in Uganda is highly uniform. This is good news, as breeding efforts will be well focused.

IPM research program on major insect pests and diseases of coffee

Collaborative linkages were established between the major coffee stakeholders in East Africa, including regional coffee networks and coffee research institutes. Discussions were held with the following regional stakeholders: David Roche, Coffee Quality Institute; Chris Kosnik, Coffee Corps; Clive Drew, Nathan Uringi and Daniel de Reuck, APEP Project, Kampala; Dennis Garrity, Fabrice Pinard and Jean Marc Boffa, ICRAF; James Ogwang, Director, Coffee Research Institute Uganda and staff; Fred Magino, O.S.K Kisango and Steve Maro, Tanzania Coffee Research Insitute, Lyamungu; and Joseph Kimemia, Chrispine Omondi, Harrison Mugo, Kenya Coffee Research Foundation.

Regional Integrated Pest Management Research and Education for South Asia

Ed Rajotte, Penn State University

The Collaborative Program

Collaborators: George Norton- Virginia Tech, Sally Miller-Ohio State, Short Heinrichs-Consultant, S. Mohankumar, Site Coordinator (TNAU, India), Gregory C. Luther (AVRDC, Taiwan), Naidu Rayapati (Washington State University), Luke Colavito, Site Coordinator (WinRock International, Nepal), A.N.M. Karim, Site Coordinator (BARI, Bangladesh).

The regional IPM program for South Asia addresses pest management issues for high value vegetable crops as well as coffee. Presently the region spans the area from the Himalayan Mountains to southern India and east to Bangladesh. The region includes heterogeneous low land and mountainous ecosystems with highly diverse human societies. In these settings, seasonal crops contribute to income and exports, help reduce poverty and food insecurity, and provide engines of growth for lagging regions. Vegetables, especially in peri-urban situations provide a marked increase in income for the farmer compared with traditional broad-acre crops such as rice. The commonality among vegetable species and varieties as well as their associated pest complexes makes regional collaboration a good way to bring efficiency to IPM research and technology transfer. The South Asian regional program focuses on solanaceae, cucurbits, protected agriculture, beans, and other vegetables of local importance. It involves a comprehensive participatory approach that builds on past successes, is multi-disciplinary, and improves environmental quality through reduced pesticide use and biodiversity monitoring.

The project is an expansion of more than 13 years of prior IPM CRSP work in the region. Lessons learned have been brought to bear in the present project. The emphasis on a regional focus rather than a country focus allows better technology transfer throughout the region. IPM in region can dramatically influence agricultural trade, allowing IPM grown crops to meeting the increasing restrictive demands of the market for safe food with no or low pesticide residues.

IPM Constraints Addressed

Main constraints for vegetable cropping systems include:

(i) identify and quantify factors influencing pest problems in vegetable production systems using participatory methods;
(ii) adapt and transfer ecologically based IPM knowledge and devise IPM solutions;
(iii) test these on farmer fields; and
(iv) promote outreach and dissemination through collaboration with NGOs and governmental technology transfer entities.

Additional constraints addressed by the regional project include:

(i) The best means of transferring farmer-friendly IPM technologies be efficiently developed and transferred;
(ii) Quality control of IPM inputs, especially imports;
(iii) Building local capacity in IPM research and technology transfer;
(iv) Means of increasing regional export of IPM crops by addressing pest issues arising in crops important in the export seasons;
(v) Collaborating with global issues such as IPM evaluation and insect transmitted plant viruses; and
(vi) Use of IPM-based knowledge to help build sustainable economies and communities.

India

IPM Activities

The key constraint observed in South India was the need for IPM solutions to specific pest problems in vegetables. The need for IPM solutions in South India vegetables appear to be greatest in eggplant (brinjal,) okra (bhendi or lady finger) and tomatoes.

The key pests identified on these crops were:
Okra (Bhendi): Helicoverpa armigera, Earias spp., *Tetranychus urticae,* yellow vein mosaic and weeds.

Eggplant (Brinjal): Leucinodes orbonalis, Epilachna viginctioctopunctata and fusarium wilt.

Tomato: Helicoverpa armigera, Bemisia tabaci, Tetranychus urticae, Spodoptera litura, thrips transmitted tospovirus, and weeds

Network Establishment

An initial visit was made to India during June-July

2006 by Ed Rajotte, Greg Luther, E. A. Heinrichs and Naidu Rayapati. The purpose of the visit was to develop a network of institutions and to discuss with scientists the importance of the major vegetable crops, the major pest constraints and the priority needs for research to solve the major pest constraints.


Woman harvesting okra.

Leveraging Funds: The Agriculture Knowledge Initiative (AKI)

In June 2005, the Indian Ambassador to the U.S. expressed interest in renewing the partnership between U.S. and Indian universities to address some of the critical food and agriculture issues affecting India. The Ambassador indicated that U.S. Land-Grant universities were the key to the creation of the Green Revolution which transformed the Indian food system into a viable and productive enterprise. The Prime Minister of India during his visit to the U.S. expressed a need to strengthen U.S. India collaboration by renewing the U.S. India University relationship. As a result the U.S./India Agriculture Knowledge Initiative (AKI) was created.

With the objective of leveraging funds to enhance our efforts in the management of insect-transmitted viruses in Indian vegetables, IPM CRSP South Asia PIs Ed Rajotte, Penn State University Entomologist and Naidu Rayapati, Washington State University Plant Virologist submitted a successful proposal to the USDA for support by the U.S. - Indian Agricultural Knowledge Initiative.

The proposal entitled *"Improving the Capacity for Integrated Pest Management of Insect-borne Viral Diseases in Indian Vegetable Production"* will address institutional capacity building and vegetable IPM technology development via the following objectives: (i) Create a community of expertise between India and U.S. for the integrated management of vegetable insect-transmitted viruses, (ii) Provide a 6 month training experience for two Indian scientists in the U.S., one with Prof. Naidu Rayapati (virus-vector biology) at Washington State University and one with Profs. Fred Gildow (virus-vector biology) and Ed Rajotte (entomology) Penn State University and (iii) Conduct a 4 day workshop in India on virus detection, diagnosis and management in South India in 2007. Complementary funds for this project are being sought from the Indian Government for this project by the TNAU IPM CRSP India Site Coordinator.

Seasonal pest calendar

Based on discussions with stakeholders a seasonal calendar of pest activity was developed to serve as guide for developing research studies to be conducted on bhendi, brinjal and tomato in the Dharmapuri and Krikshnagiri districts, Tamil Nadu.

Table 1. Seasonal Pest Calendar for Coimbatore, Dharmapuri and Krishnagiri District, Tamil Nadu, India.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Major Crops and Pests												
Bhendi (Okra)												
Helicoverpa armigera			X	X	X			X	X	X	X	
Earias spp.		X	X	X			X	X	X			
Tetranychus urticae				X	X	X			X			
Yellow vein mosaic			X	X	X	X						
Brinjal (Eggplant)												
Leucinodes orbonalis	X	X	X	X	X	X	X	X	X	X	X	X
Epilachna vigintioctopunctata				X	X					X	X	
Fusarium wilt		X	X	X						X	X	
Tomato												
Helicoverpa armigera			X	X	X			X	X	X	X	
Bemisia tabaci			X	X	X	X						
Tetranychus urticae			X	X	X	X			X	X		
Thrips transmitted tospovirus			X	X	X	X						
Spodoptera litura			X	X	X			X	X	X	X	

Nepal

Regional IPM Research and Education Program for South Asia extends and replicates the participatory IPM approach in Nepal. It also strengthens the network of linkages in IPM knowledge and expertise across South Asia. Participatory appraisals, baseline surveys, and crop pest monitoring are in priority to vegetable crops, spices, tea, coffee and medicinal plants. Farmers' response on different components of pest management practice when demonstrated on farmers field are encouraging. Technology transfer is already in operation through WI, IDE, SIMI, CEAPRED, SAPPROS, and AEC however technology collaboration with Department of Agriculture and Nepal Agriculture Research Council (NARC) is in progress. These organizations have worked with tens of thousands of farmers in Nepal. With the help of Winrock International, IPM CRSP is successful in stimulating small business development for IPM inputs such as sex pheromone traps, bio-pesticides and bio-fertilizers. The project has initiated to establish a
national network of IPM expertise in collaboration with DOA and development for graft technology with Nepal Agriculture Research Council.

Network establishment

IPM CRSP has initiated a national network of IPM expertise. In this regard, the name of participants in the National Conference on Integrated Pest Management held during August 25-26, 2006 was recorded (164 attendees). The conference received financial support from IPM CRSP. USAID mission has been updated with IPM activities

A three member team with Dr. Luke A. Colavitto, Mr. B. K. Gyawali and Mr. R. B. Shrestha participated in program planning at BARI in March 2006

A cross project IPM meeting was held before IPM CRSP planning meeting in Dhaka, March 2006. The group decided to integrate Nepal IPM CRSP activities with existing WI Ag Projects through team leaders for TCGDA– Mr. R. B. Shrestha, SIMI – Mr. Bhuwan Bhatt, UJYALO – Mr. Ganesh Ghale and BDS MaPS – Mr. Narendra Raisali

Progress

Graft technology information was made available through electronic mailing services from BARI, Bangladesh. Information from the IPM related work plan and progress was made by request from the cross projects of WI Agriculture. The Nepal IPM

CRSP work plan and budget was prepared. A base line data collection questionnaire obtained from Virginia Tech was further improved based on Nepalese cropping patterns and problems. IPM CRSP sponsored the National Conference on Integrated Pest Management (NCIPM) held during August 25-26, 2006 in Kathmandu, where supply chain development for effective delivery of IPM technology was prioritized.

Cross Project IPM Activities in UJYALO

Vegetables in ten districts of Nepal

1. Two trainings to agro-vet personnel on pesticide management were done at different locations and period.
2. Twenty-seven trainings were given to master leader farmers on pest and disease management.
3. Hundred and fifty-four farmers received training on insect pest management at different times in ten districts.

Coffee

1. Ten farmer trainings were performed on organic fertilizer at pocket level.
2. Seventeen trainings were given to farmers on disease and pest management especially for bees, which helps in pollination and increased yield during flowering.
3. Thirty mobile trainings were given to farmers.
4. Eighteen trainings on organic fertilizers were given to farmers.
5. Two trainers' trainings (TOT) were given to twelve leader farmers on organic fertilizer.
6. Twenty trainings were given on disease and pest management.
7. Forty-eight field level agriculture mobile training was carried out based on problems.
8. Four trainings were carried out on shade management
9. One research and development was performed on bio-fertilizers and bio-pesticides
10. Research and development was carried out on white stem borer of coffee at four locations.

IPM Activities in TCGDA
Coffee

1. Three trainings were given to input service providers on bio-fertilizer and bio-pesticide handling.
2. Seven trainings were carried out on preparation and application of bio-fertilizers and bio-pesticides.
3. Eight different trainings were performed through group mobilization on pruning management of coffee stem borer.
4. One training was performed on "Bocasi", vermin-compost and bio-fertilizers.
5. Six dealers of bio-fertilizer and bio-pesticides were supported for their establishment
6. One campaign of pesticide awareness was launched on tea

IPM activities in BDS MaPS (NTFPs)

1. Hundred and fifty trainings were carried out on disease and pest management out of which Districts Banke had 31, Bardiya 5, Surkhet 11, Kailali 46, Syangja 35, Dolpa 9 and Darchula 12.

IPM activities in SIMI
Vegetables

1. Eighty-seven efforts were made to strengthen supply chain development in integrated pest management technology.
2. Thirty eight soil solarization trainings were demonstrated in farmers field
3. Four trainings were given to farmers on soil solarization.
4. Thirty IPM villages were developed as demonstration plots.
5. Fourteen trainings were carried out on plant protection measures
6. Two hundred and forty three mobile trainings were given on integrated pest management.
7. Hundred and twenty-five mobile trainings were conducted in farmers field on soil solarization.
8. One technical training was given to input suppliers in pesticide handling.

Farmer to farmer (FTF) program

Volunteer's service was made available for a specific area and problems. IPM is given a major emphasis in all the assignments. FTF program is very useful to Nepalese farmers in solving the major problem.

Ms. Yvonne as a Plant Quarantine and Phytosanitory volunteer provided the service for a period of two weeks.

Dr. James C. Correll, contributed as a volunteer in solving the problem of *Plasmodiophora brassicae*, club root disease of crucifer vegetables.

Ms. Ann L. Hazelrigg, served as volunteer for the management of tomato disease.

Gerald William Hayes Jr. who helped in solving the problem of honeybee and diseases and parasite management at Gorkha bee farm, Bharatpur Yagyapuri, Chitwan.

Dr. James R. Burleigh specialized in plant pathology and Dr. Donna R. Shanklin in Entomology served for a period of two weeks in the field of integrated pest and disease management of vegetable crops.

Development of IPM components

Alternative to chemical pesticides and fertilizers were introduced across the projects. In order to support the mission bio-pesticides, bio-fertilizers and pheromone traps were found effective in minimizing the use of toxic chemicals across the projects. Development and introduction of graft technology in tomato and eggplant is expected to further improve the on going effort of the supply chain of IPM technology in project districts.

Pheromone trap to attract and kill insects.

Training for capacity building

Nepal IPM CRSP has a definite plan to train NARC scientist on graft technology at BARI in Bangladesh. These scientists will develop confidence on return after confidence development these scientists will train to nursery growers, agriculture technician and agriculture officer across the projects. During the final stage of IPM CRSP, training workshop will be organized on pest and disease diagnostics in order to strengthen supply chain of IPM technology.

In this context, Mr. Nagendra Subedi, a Nepalese student received scholarship for his higher study in Ohio State University, USA as a part of IPM CRSP support. He was updated on technical issues of Nepal IPM CRSP from Nepalese professionals before departure to USA during August 2006. The support is considered as strong linkage of collaboration. Nepal IPM CRSP also supported him for air ticket for his travel from Kathmandu to USA.

Bangladesh

The IPM CRSP activities were carried out as a collaborative effort mainly among the scientists and extension personnel at the Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI), Mennonite Central Committee (MCC-Bangladesh, NGO), CARE-Bangladesh (NGO), ActionAid-Bangladesh (NGO), Practical Action-Bangladesh (NGO), International Rice Research Institute (IRRI), Penn State University, Ohio State University, and Virginia Tech. ANM Rezaul Karim served as Site Coordinator and Edwin G. Rajotte as Site Chair.

Survey for assessing pest status of different mite species and develop IPM package for their management: Survey activities at 15-day interval were started from December 2006 in nine locations of Gazipur, Jamalpur, Comilla, Narsingdi, Chittagong, Jessore, Bogra, Natore, and Rangpur districts to record the incidence of white fly in eggplant, chili, cucurbits and beans. Records of the incidence were taken by visiting farmer fields as well as through a prefixed questionnaire. The survey will be continued for both winter and summer seasons.

Evaluation of eggplant and tomato varieties /lines for their resistance to bacterial wilt disease (BW) and root knot nematode (RKN): During 2005-2006 winter season, 23 eggplant lines and 60 tomato lines were tested in artificially inoculated BW sick-bed having an estimated BW inoculum of about $1.7x10^8$ CFU/ml of water by dilution method. Immune or highly resistant materials were not available. Four accessions (BL-072, BL-114, BL-118, and 1x6) showed resistant reaction (20% infection). In tomato, four accessions (VRT-010-1-1, WP-1, WP-7 and 7x10) showed resistant reactions (10-20% infection).These lines will be selfed for purification and further trial for confirmation.

For resistance to root knot nematode, twenty lines of eggplant and 48 lines of tomato were evaluated during 2005-2006 winter season against RKN in infested sick-beds having an estimated population 3000-4500 larvae of RKN per Kg of soil. The root systems of the plants were indexed 45 days after planting on a 0-10 scale, 0 indicating high resistance and 10 highly susceptible. Among 20 eggplant entries, only one (BL-113) showed resistance and 12 were moderately resistant. In tomato, three accessions (WP-4, 7X10, and 5x6) were resistant and 17 were moderately resistant.

Grafting of watermelon with cucurbit rootstocks for controlling *Fusariuam* wilt disease (FW): *Fusarium* wilt disease (*Fusarium oxysporum f.sp.niveum*) is a serious constraint for the cultivation of water melon in Bangladesh. Farmers fail to obtain satisfactory control of the disease even with repeated applications of fungicides. There are cucurbit (sweet gourd and bottle gourd) varieties available in Bangladesh that are highly resistant to FW. To find out the grafting compatibility and success, one pure line selection of sweet gourd (PKDS-187-9-A-4-6-4-1) and one variety of bottle gourd (BARI Lau-2) were used as rootstocks and a Japanese hybrid water melon variety (Top Yield) was used as scion. Up to December 2006, 400 grafts were made using sweet gourd as rootstock and another 400 with bottle gourd as rootstock. The grafted plants will be planted in the main field after about one month and their performance will be compared with non-grafted ones.

IPM package for the control country bean, cabbage and tomato: The activities for developing IPM package for country bean were conducted at BARI farm, Jessore and in farmers' fields at Gaidghat site of Jessore with two treatments: (a) Destruction of infested flowers and fruits by hand-picking and weekly release of the egg parasitoid (*Trichogramma evanescence*) at the rate of one gm. of parasitized eggs/ha/week, and release of the larval parasitoid (*Bracon habetor*) at the rate of 800-1000 adults/ ha/ week; and (b) Farmer's practice of spraying synthetic parathyroid insecticide at 3-day interval. The experiment is on-going.

The activities for developing IPM package for cabbage/cauliflower were started at BARI farm, Jessore and in farmers' fields at Goispur village in Bogra district with two treatments: (a) Destruction of infested leaves by hand-picking and weekly release of the egg parasitoid (*Trichogramma evanescence*) at the rate of one gm. of parasitized eggs/ha/week, and release of the larval parasitoid (*Bracon habetor*) at the rate of 800-1000 adults/ha/ week; and (b) Farmer's practice of spraying synthetic pyrethroid insecticide at 3-day interval. The experiment is on-going.

The work for developing IPM package for tomato was started at the BARI farm at Gazipur and Jessore and in farmers' fields in Rampur village of Jessore with two treatments: (a) Destruction of infested leaves by hand-picking + weekly release of the egg parasitoid (*Trichogramma evanescence*) at the rate of one gm. of parasitized eggs/ha/week, and release of the larval parasitoid (*Bracon habetor*) at the rate of 800-1000 adults/ha/ week, + use of *Helicoverpa* pheromone trap at $10M^2$ distance; and (b) Farmer's practice of spraying synthetic parathyroid insecticide at 3-day interval. The experiment is on-going.

Development of techniques for mass-rearing of green lacewing and lady bird beetle (predators), and different species of egg and larval parasitoids (*Trichogramma* species) and evaluation of their efficacy in greenhouse and field: Mass-rearing of green lacewing and lady bird beetle (predators) were started in the IPM laboratory of BARI at Gazipur. Eggs of *Corcyra cephalonica* are being used for rearing green lace wing (*Chrysopa* sp.). Two species of lady bird beetle are being reared on mealy bugs (host pumpkin).

Mass rearing of four species of *Trichogramma* (*T. chilonis*, *T. evanescence*, *T. graminis*, and *T. bactrae*) were started on *Corcyra* eggs as well as on the eggs of *Sitotroga oryzae*. Mass-rearing of *Bracon habetor* (larval parasitoid) was also started on the larvae of *Galleria* sp. and *Helicoverpa armigera*.

Simultaneously, micro-plot study to evaluate the efficacy of the parasitoids were initiated at BARI farms in Gazipur and Jessore for controlling eggplant fruit and shoot borer (*Leucinodes orbanalis*), armyworm and diamondback moth (*Plutella xylostella*) of cabbage, pod borers of country bean (*Maruca vitrata*, *Helicoverpa armigera*), fruit borer of tomato (*Helicoverpa armigera*).

Mutuality of Benefits of the Research

The pest problems assessed in these studies are common and widespread in Asia and also in other parts of the world. IPM approaches to manage these problems have broad applicability, especially in Asia. The cultivation and consumption of vegetables are growing in Bangladesh and the region. The primary feedback in terms of benefits to the United States will be through (a) the effects of economic growth in the region on trade and demand for U.S. products in international markets and (b) improved relations in a politically sensitive area of the world.

Pheromone, Cuelure

Of particular interest is the desire of the government of Bangladesh to purchase a large quantity of Cuelure from a U.S. company. The Cuelure will be used to suppress populations of fruit flies that attack cucurbit crops. The Cuelure purchase is a direct result of the successful experiments, demonstrations and trainings carried out by the IPM CRSP team and partner NGOs and DAE.

Institution Building

Funds were provided for vehicle repair and maintenance, and rental to facilitate transport to and from research sites. Expenses for greenhouse and laboratory renovations, purchase of computer accessories, and various supplies were provided. US scientists provided research supplies, such as, synthetic pheromone for cucurbit fruit fly and sticky traps for white fly monitoring. Bibliographies prepared at Penn State University were also sent to the scientists. The Penn State University also supplied to the BARI central library as many as 486 old issues (1968 to 2003) of 10 international periodicals (Evolution, Annals of Ento. Soc. America, Annual Rev. Entomol., Environ. Entomol., Journal Econ. Entomol., Journal Insect Physiol., Molecular Biol. Evolution, Systematic Biol., Systematic Zool., and The State of Site-specific Management Agril.).

Human Resource Development

Degree Programs: IPM CRSP supported three Bangladeshi students to pursue and complete PhD and MS degrees in 2005-2006 period. Ms. Shamsunnahar completed PhD degree in plant pathology (nematology) in February 2006 through a sandwich program between BSMR Agricultural University in Bangladesh for course work and Ohio State University for thesis research. In a sandwich program, two Bangladeshi scientists, A. K. M. Salim Reza Mollik for MS in horticulture and A. K. M. Khorsheduzzaman for PhD in entomology were supported to pursue their degree programs at the BSMR Agricultural University in Bangladesh. They carried out part of their thesis research at the Tamil Nadu Agricultural University in India. Mr. Mollik would defend his thesis research and complete the MS degree in May 2007. Mr. Zaman would defend his thesis research and complete the PhD degree in June 2007.

Networking Activities

Networking is accomplished through institutional collaboration among BARI, BRRI, UPLB, BSMR Agricultural University in Bangladesh (BSMRAU), CARE-Bangladesh Mennonite Central Committee (MCC)-Bangladesh, and IRRI-Bangladesh. IRRI and AVRDC play key role in networking with other countries in the region. Scientists involved in the project work throughout the region and can spread research results through visits to other countries and participation in workshops, meetings, and other networking activities. U.S. universities also help with networking in the region. Some of the scientists on the project also work with the Philippines site, including the weed scientist from UPLB working in the Bangladesh site. The site coordinator has networked with other host countries and foreign supported projects in the country, both hosting them at the IPM CRSP site, and attending meetings in which multiple organizations are represented.

Ecologically-Based Participatory IPM for Southeast Asia

Michael Hammig, Clemson University

The Collaborative Program

Indonesia and the Philippines are the selected host countries for this project. Both countries have large agricultural sectors that provide the bulk of food needs for their large and growing populations, and they are ecological "hot spots" for losses of biodiversity. Vegetables and other high-value crops are typically produced by communities of intensive small farm operations located in ecologically sensitive areas. Families depend on farm revenue as their major – often exclusive – income source. Therefore, production risk issues are of paramount importance, and pest management ranks as the most important source of production risk.

The problems encountered in Southeast Asia that this project addresses are the result of excessive indiscriminate use of synthetic chemical pesticides to control agricultural pests. This pattern of excessive pesticide use is replicated across crops in virtually all agricultural production areas in the region. Vegetables have much more complex pest problems than for staple crops such as rice, and the use of synthetic pesticide use by vegetable farmers is much more intense.

The project includes seven research activities across nine research sites. In the Philippines, research will focus on IPM for tomato and eggplant in Batangas, Nueva Ecija, and Nueva Viscaya Provinces; strawberries in Benguet Province; and rice/vegetable systems on Mindanao. In Indonesia, research on vegetable IPM will be centered in North Sumatra, North Sulawesi, and West Java. Cocoa IPM will be studied in North and South Sulawesi, and the rice/vegetable system work will be replicated in Lampung Province.

The project also includes activities to ensure that the research is participatory, involving farmers, extension workers, NGOs, IARCs, and national research agencies, as well as scientists from U.S. universities and USDA. Field research is targeted to activities that directly address farmer needs, while providing ancillary benefits to the environment, rural communities, and consumers. Social scientists assess IPM systems in terms of economic impacts and changes in the social dynamics of farm communities. Gender studies address the role of women in agriculture, and the effect of changing women's roles as IPM systems are implemented.

Education activities are a cornerstone of the project. Adoption of IPM requires innovative programs of farmer training and communications. Training of field workers and future IPM scientists is needed to ensure the future of IPM development. Communication across the many research/demonstration sites is promoted to create opportunities for synergistic efforts in the Southeast Asia region.

IPM Constraints Addressed

Specific pest problems differ from location to location throughout the Southeast Asia region; in general, however, these problems are the result of excessive indiscriminate use of synthetic chemical pesticides to control agricultural pests. Both Indonesia and the Philippines have undertaken successful efforts to provide IPM training to farmers, but these efforts have largely focused on rice. Vegetables and other crops have much more complex pest problems than rice, and synthetic pesticide use by vegetable farmers is much more intense than for rice.

Chemical pesticides are becoming more expensive (especially new chemistries) and add significantly to production costs. Pest resistance and elimination of natural enemies are common problems. In addition, inadequate attention to proper application and disposal techniques lead to direct health impacts on farmers and farm laborers. Contaminated water supplies endanger rural communities and downstream ecosystems. Rural social structure is affected by health problems, and the effect of agricultural chemical use on women's roles in farming and farm communities are a significant concern. Pesticide residues present health problems for consumers and restrict marketing options, especially for potentially lucrative international trade markets. These problems are well understood and the benefits of effective IPM systems to change this pattern of behavior are well documented.

Development of IPM systems for vegetables and other high-value crops presents challenges to researchers, but the payoffs are substantial. The objectives of the project will be attained by focusing research and training efforts in selected important growing areas in Indonesia and the Philippines. In the Philippines, in collaboration with the University of the Philippines at Los Baños (UPLB), PhilRice, IRRI, Local Government Units, and AVRDC, sites are located at Batangas, South Luzon; Benguet, Nueva Viscaya, and Nueva Ecija, Central Luzon; and Arakan Valley, Mindanao. In Indonesia, primary collaborators, in addition to the Indonesian Ministry of Agriculture Agency for Agricultural Research and Development, are Insitut Pertanian Bogor (IPB) [Bogor Agricultural University] in West Java, Sam Ratulangi University (Unsrat) in North Sulawesi, Hasanuddin University (Unhas) in South Sulawesi, and the Regional Development Planning Board, FIELD Indonesia, and Development Alternatives Inc. (DAI) in North Sumatra. The major vegetable and selected other high value crops in each region are the focus of IPM development through research, field demonstrations, direct farmer training, institutional capacity building, and establishment of a regional communications network for the exchange of ideas and accomplishments.

Research Achievements

Parasitoids for biological control of the potato leafminer

Understanding the basic biology of a parasitoid is essential in being able to use or encourage populations of this natural enemy against a pest. The potato leafminer, *Liriomyza huidobrensis*, is the most important leafminer pest of vegetables in Indonesia. It attacks several crops in addition to potato. The parasitoids, *Hemiptarsenus varicornis* and *Opius chromatomyiae,* were the two most important natural enemies of *L. huidobrensis* in West Java. This is based on collections of leafminer larvae and pupae and holding them in the laboratory for emergence and subsequent identification of the parasitoids. Level of field parasitization by both species of parasitoids averaged 60-70%. Based on field observations, applications of broad-spectrum chemicals have been found to virtually eliminate the parasitoids and allow leafminer populations to resurge.

Laboratory studies revealed that developmental time from egg to adult for *H. varicornis* was about 16.15 days and the longevity of females and males was 26.35 d and 2.72 d, respectively. The average fecundity of a female was 51.65 eggs with the percentage of males making up about 47.07 %. Throughout her life, each female parasitoid killed an average of 143 leafminer larvae by host-feeding, and/or oviposition.

Developmental time for *O. chromatomyiae* from egg to adult was 13.59 days. Each female parasitoid produced an average of 113.0 progeny during her lifetime. Sex ratios of the offspring were highly biased in favor of females (73.5%) and mean adult longevity was 10.80 and 13.90 days for females and males, respectively. These basic biological data are important for understanding how leafminer natural enemies can be manipulated to suppress leafminer populations.

Nuclear polyhedrosis virus for control of Spodoptera exigua

The nucleopolyhedrovirus of *S. exigua* was isolated from infected larvae collected from onion fields in Cipanas, West Java. The virus has been successfully propagated in the laboratory and virus stocks have been prepared for use in field tests. Field tests to evaluate this virus against *S. exigua* populations in leaf onions will be conducted in November, 2006.

Integrated Pest Management of sweetpotato weevil

There are many strains of entomopathogenic fungi and their efficacy varies widely against a target host. The approach for managing sweet potato weevil, *Cylas formicarius*, in sweet potato is to locate the most virulent strain of the fungus (*Beauveria bassiana*) against the weevil. Several isolates of this fungus have been collected from the field on infected weevils. Techniques for propagating of this fungus have been developed in the laboratory. Fungal isolates are now being tested for their efficacy against the weevil in the laboratory. The next steps will involve improving production methods for the fungus and testing them in small field plot tests to determine which fungal isolates can be used in a pest management program to suppress weevil populations.

Monitoring of crop pests and their natural enemies in selected vegetables

Major vegetable crops were surveyed in the Puncak area of Bogor, province. In green onion, major insect pests included the leafminer, *L. huidobrensis*, the beet armyworm, *Spodoptera exigua* and the black aphid, *Neotoxopthera formosana*. Carrots have almost no insects that cause significant damage to the foliage and the loopers that are found there are highly infected with a polyhedrovirus or with fungal pathogens such as *Nomurea rileyi*. Major pests include root knot nematodes and a condition in carrots that causes the roots to become forked and unsalable. Broccoli is commonly impacted with clubroot with insect pests that include the diamondback moth, *Plutella xylostella* and *Crocidolomia pavonana*. The major pest of celery is the leafminer, *L. huidobrensis*. This pest also attacks cucumber as does bacterial wilt, powdery mildew and a yet unidentified pest that causes the pods of Japanese cucumber to become bent and deformed. Chilies are most often infected by both tospoviruses and geminiviruses. The main fungal pathogen is anthracnose. Chinese cabbage or pak choi, as with broccoli, has clubroot but also is infested with flea beetle (*Phyllotreta vitta*) and the cluster caterpillar, *C. pavonana*. Weeds are a major pest in all vegetable crops.

IPM for control of the Cocoa Pod Borer

A major control tactic for the cocoa pod borer (*Conopomorpha cramerella*) is chemical insecticides, which largely have not been effective. Thus the plastic sleeves are placed on the young, developing pods to prevent the CPB moth from laying eggs there. The plastic sleeves, however, are a significant source of pollution. We contacted and arranged for plastic sleeves to be shipped from Degradable Polymer Products Incorporated (DPPI) to collaborators at Hasanuddin University. Results from experiments that were carried out in cocoa plantations in S. Sulawesi, showed that the use of the degradable plastic sleeves reduced attacks by the cocoa pod borer from nearly 100% in the controls to below 15% in the sleeved cocoa pods. The addition of extracts of "Maja" (a calabash-type tree, probably *Cresentia alata*), and neem along with degradable sleeves further reduced damage by CPB and pod-infesting fungi to below 5%. Applications of entomogenous nematodes (*Steinernema carpocapsae*) along with the degradable sleeves, also significantly increased fresh bean weight over either plastic sleeves alone or nematodes alone. Degradable sleeves break down to carbon dioxide and water and disappear after about 4 months with no residue. Tests are underway to expand the use of the degradable sleeves to larger areas of Indonesia, Philippines and Malaysia. Surveys of abandoned cocoa orchards in N. Sulawesi revealed that from 30 - 70% of the eggs of CPB were parasitized by *Trichogramma* sp.

Support for this activity was "leveraged" with support from DPPI ($36,000), MasterFoods, Inc. ($5,000) with laboratory and field experiments being carried out at Hasanuddin University in Makassar, South Sulawesi and in N. Sulawesi through the University of Sam Ratulangi, Manado. Except for travel for the Clemson scientists, no other USAID funds were expended on this effort.

On Farm Research

Citrus IPM in North Sumatra

Farmer-participatory field study on citrus falling fruit was conducted in two sub-districts in Karo: Tiga Panah and Barus Jahe. The field study in Barus Jahe was conducted in Suka village, joined by participants from 4 villages (Barus Jahe, Tiga Jumpa, Paribun, and Sukajulu), while field study in Tiga Panah was conducted in Suka village, joined by farmers from 2 villages (Suka and Salit). The study showed that citrus falling fruit in the study sites was caused by several factors but the Asian papaya fruit fly, *Bactrocera papayae*, is the major cause. Fruit collections were made in citrus orchards this year and infested fruit was held for the flies larvae to pupate and for flies to emerge. When flies emerged, species identification was confirmed by Dr. Richard Drew of the International Centre from Management of Pest Fruit Flies, Griffith University, Nathan Campus in Brisbane, Australia. Also, damage by this pest was estimated at about 20% based on transects of orchards. An unknown lepidopteran larva also was seen infesting fruit but, to date, this has not been identified. *Bactrocera papayae* (and other related species) have been effectively managed in other citrus growing areas of the world by orchard sanitation (removing infested fruit), harvesting fruit as soon as possible to avoid infestation, and strategic applications of protein bait sprays that do not affect natural enemy populations but effectively suppresses fruit flies. Traps can be used to monitor fruit fly activity. Effective IPM options for fruit fly management are available to Karo citrus growers but this will require an "area wide" approach with all citrus growers participating. Otherwise, fruit flies will continue to move from heavily infested areas into the fruit fly "free" area.

Management of major pests of tomato and eggplant

Disease and Insect Management: This project is being carried out in Tanauan, Batangas Province, Philippines. Tanauan is a major vegetable production area and trade center. Tomatoes and eggplant are the target vegetables for this activity. The benchmark Participatory Appraisal revealed that the majority of farmers (69%) owned their land. Nearly 50% of them had at least a high school education and 97% of the farmers applied pesticides from 1 – 10 times per season. Eighteen percent applied chemical pesticides more that 10 times per season. Most of the farming activities are carried out by male farmers but females are involved in harvesting and decisions about marketing.

Five field demonstration sites were set up with farmers participating. Direct comparisons were made to farmers' usual practice. These demonstration areas were used to train farmers as well as extension personnel. The local government officials were full partners and were very supportive of these activities. Using grafting technology developed at AVRDC and tested earlier in other areas of the Philippines, resistant eggplant rootstock was used to graft the popular 'Diamante' variety of tomato. Casino, a popular variety of eggplant also was grafted onto resistant rootstock. However, later in the season, the "resistant" eggplant also was infested by *Ralsonia*. This strain, from the Cale site, is being studied in the laboratory by Dr. Nenita Opina. The project was "re-launched" in July, 2006 when the Clemson team visited the area. Because of typhoon "Milenyo", harvest of tomato was not possible but observations in the demonstration plots revealed that the grafted tomatoes and eggplants were much healthier with lower incidence of water-logging and plant pathogens than in the non-grafted ones. Other observations revealed that ants (*Solinopsis gemminata*) were inflicting damage to about 10% the tender shoots of younger egg plants. This may be the first report of this phenomenon. Damage by ants was not so apparent on older eggplants.

Weed Management: Farmers usually control weeds in their vegetable fields by hand weeding from 5 to 16 (weekly) times throughout the season. This is not only expensive but also tedious and time-consuming. In crops with low weed competing ability like onions, weed control costs consist of 20% of total production costs. To determine the efficacy of stale-seedbed technique, compared to farmers' practice, in reducing weed populations and reducing weed control costs in eggplant a study was conducted in five farmers' fields in Tanauan City, Batangas province in the Philippines from May to September 2006. Five cultivars of eggplant were grown 1) according to common farmers' practices and 2) according to IPM CRSP that employs the "stale seedbed" technique.

Although yields did not differ much between the two treatments, weed control costs in the stale-seedbed plots were 56% lower than weed control costs in the farmers' practice plots. Total production costs in stale-seedbed plots were about 30 % lower than production costs in farmers' practice plots. The net profits in the stale seedbed plots were higher by more than two-fold compared to net profits in the farmers' practice plots. Net profits from the EG 203 cultivar where the stale seedbed was used yielded a four-fold higher net profit than from the same cultivar under usual farmers' practice.

The local variety Casino is the most desired by consumers in the region. That variety, under usual farmer practice, is not profitable. Using the stale seedbed approach Casino becomes profitable. When Casino is grafted to EG 203 rootstock, potential profits under the stale seedbed approach increase substantially.

Storage, multiplication, and delivery of improved and landrace seed

This was initiated by establishment of a Community Seed Bank (CSB), which involved seed health training and monitoring of field planted to upland rice varieties for multiplication and storage before the next cropping season. A total of 30 upland rice farmers have registered as formal members of the CSB. Among those, 25 produced high quality seeds in 2005 and were awarded plastic storage bins from their good crop. The CSB continues this year with plantings on cooperating farms in seven villages. Four upland rice varieties, Dinorado, NSIC Rc 9, NSIC Rc 11, and UPL Ri 5, were planted on March 6. The CSB is the outcome of participatory methodologies applied in the Consortium for Unfavorable Rice Environment project. In previous focused group discussions conducted by the team, farmers identified poor seed quality as a constraint to improved productivity. The team at Arakan Valley followed up on that feedback by introducing seed health practices that are institutionalized in the CSB framework. Seeds are therefore available on a sustained basis. The project has even attracted investors seeking high quality seed to meet the demand of markets. Through this activity, the team is promoting *in situ* conservation of farmers' preferred traditional and modern varieties through the CSB, and devising effective seed storage, multiplication and distribution systems in cooperation with the local government unit. Farmer participatory experiments (FPE) and training for seed health management among farmers are being continued.

Analysis of functional and genetic diversity of traditional and improved rice germplasm

Seeds of 41 out of 42 traditional varieties for analysis of resistance to rice blast and brown spot disease have been sent to IRRI after compliance of all documents for transfer of seeds to IRRI. The genetic diversity of these traditional varieties will be analyzed using microsattelite markers after extraction of their DNA. This work is in progress at IRRI.

Market in the Philippines.

Participatory Research

Evaluation of temporal and spatial deployment methods for rice and vegetables in rubber plantations for improved IPM in participatory research programs with farmers

A crop diversification scheme that includes planting rice and vegetables intercropped with young rubber trees has been evaluated. The objectives included determining performance of rice and mungbeans as a function of rubber tree age, both in monoculture bands and in mixed bands of rice varieties and rice-mungbean intercrops. It was to determine the IPM needs for these systems and develop strategies to meet them. Farmers' fields from three municipalities of Antipas, Arakan, and Pres. Roxas were used in the experiment. In each municipality, there was a pair of rubber plantings, one field with 1-year old rubber trees and the other field with 3-year old rubber. The pairs were selected such that the only difference between the two plantings in a pair was the age of rubber trees. Hence, there was one field (~one farmer-cooperator) in each of the three municipalities and in each of the 1- and 3-year old rubber plantings.

Surveys were made of major insect pests, plant pathogens, and weeds in each of the production systems. In the preliminary analysis, weeds were indicated as a particularly important problem, with major species including *Murdannia nodiflora, Aegeratum conyzoides*, *Borreria laevis*, *Rottboelia exaltata*, *Commelina diffusa*, and *Commelina benghalensis*.

Pest complex in La Trinidad strawberry fields

Spider mites have been identified as a major pest of strawberry in Benguet province. High market value has intensified cropping methods and exacerbated the problem. An initial survey of local farms was performed to determine the most economically important species in the region. Two spider mites species were determined to infest strawberry plants. The phenology between these two spider mite species and local strawberry production techniques are being studied to optimize efforts to control the pests. In addition determining major insect pests of strawberry in La Trinidad will help to coordinate predatory mite releases and pest treatments.

The survey was performed in five farmers' fields in La Trinidad municipality, Benguet province from January to September, 2006. Weekly surveys were conducted from January to April with monthly surveys continuing through September. The three main strawberry cultivars (Sweet Charlie, Camarosa and Strawberry Festival) were surveyed. The five farms selected were representative of the upland and lowland systems of strawberry cultivation in the municipality. Samples of spider mites from each farm were slide mounted for identification and to serve as reference specimens for the Office of the Municipal Agriculturist. The two species *Tetranychus kanzawai* and *Tetranychus urticae*, were identified infesting strawberry, with *T. kanzawai* being the primary pest species.

Mass rearing of *Amblyseius longispinosus,* a native predatory mite.

The knowledgeable strawberry farming community in La Trinidad, Benguet has realized the use of predatory mites could control spider mites and nullify current resistance issues. In the past few years several attempts have been made to import commercially available exotics without a full understanding of the potential non-target effects. Their attempts failed due to the lack of expertise in the fields of biological control and Acarology. The goal was to utilize native predatory mites rather than exotics, primarily but not limited to *A. longispinosus*

A rearing facility for the native predatory mite *A. longispinosus* was designed and implemented at the Provincial Agriculturist's greenhouse in La Trinidad in January of 2006. This facility was developed to identify unique problems involved with rearing predatory mites in the La Trinidad climate. Four host plants were tested for suitability as a host plant for spider mite production. Bush sitao, *Vigna sinensis*, was chosen as the optimum host plant for spider mite production based on local availability and suitability to the climate. Rearing benches and the predatory mite rearing method were chosen to best suit the current needs. The system developed can be expanded as space allows. The municipality will be building their own rearing facility based on these findings in January of 2007.

The University of the Philippines at Los Banos (UPLB) was initially considered as the rearing site for the predatory mite, (*A. longispinosus).* However, later it was considered impractical to ship the predatory mites from Los Banos to La Trinidad in northern Luzon. Thus, the research focus was shifted toward developing a rearing method for the predatory mites at La Trinidad.

IPM research/demonstration activities for vegetable growers in the Tondano Lake area of North Sulawesi

Tests were conducted to determine the effect of staking and defoliation of mature (bottom) leaves on tomato production in Tumaratas, North Sulawesi. Yields were significantly higher in staked tomatoes than in non-staked tomatoes (local farmer method) and there were significantly lower levels of damaged fruit in staked tomatoes. However, there were higher levels of virus infection in staked tomatoes compared to non-staked. Pruning of bottom leaves in staked tomatoes did not increase yield. Since these tests were started, many growers in the area have adopted the staking method of culture.

The green mirid, *Nisiodicoris tenuis*, is common in tomato fields in the Lake Tondano area of North Sulawesi and is known to feed on tomato blossoms and young stems. Filed tests were conducted to determine the incidence of this mirid and its effect on tomato production. Populations of the mirid were consistently higher on the local tomato variety than on the introduced (apel) variety. Populations were also higher in fields which were not regularly sprayed with insecticides. Damage to tomato plants by this insect was very low and field observations proved that it also acted as a predator.

A survey was conducted for pathogens of insect pests of vegetable crops in the Lake Tondano area. Only fungal pathogens were observed in this survey. *Nomuraea rileyi* was found to infect *Chrysodeixis chalcites, Crocidolomia binotalis, Plutella xylostella*, and *Spodoptera litura* on cabbage, and *N. rileyi* and *Metarhizium* sp. infected *Spodoptera exigua, S. litura*, and *C. chalcites* on green onions and carrots. Infection by these fungi reached levels of 25%, 25%, and 65% in cabbage, green onion, and carrots, respectively.

Studies were conducted to determine optimum conditions for rearing *Plutella xylostella* and its parasitoid, *Diadegma semiclausum*, in the laboratory. Results showed that the best cage size for rearing the parasitoid was 50X50X50cm. The average level of parasitism by *D. semiclausum* was 85.8%. Food supplements (yeast, honey, sugar water, flowers of *B. campestris*) for moths and parasitoids are also being evaluated, but tests have not been completed. Four different Brassicaceae varieties were tested for oviposition preference by *P. xylostella*. These were: cabbage (*Brassica olearacea* var. vapitata, Chinese cabbage (*B. chinensis*), caisin (*B. campestris* var. chinensis) and collard (*B. oleraceae* var. acephala). Results showed that the highest preference for oviposition was on cabbage and the lowest was on collard.

A survey was conducted to determine incidence of virus diseases in tomato and pepper in North Sulawesi. Samples of tomato and pepper leaves were collected at different sites in Manado, Tompaso, and Langowan and were sent to AVRDC for viral identification. All tomato samples were infected by gv and CMV. One sample of tomato taken from Tompaso was infected with gv, CMV, and PVY. All pepper samples were infected by CVMV except those collected from Talikuran (Tompaso). Samples of pepper plants collected from Walewanko (Langowan) and Talikuran (Tompaso) were infected with gv. Samples taken from Manado and one sample from Talikuran were also infected by PVY.

A demonstration on mass production of SeNPV was held for farmers at Modoinding. The farmers collected larvae of *S. exigua* from the field, brought them back to the house, and infected them with the virus. Infected larvae were kept in plastic bowls and held at room temperature for 3-5 days. The farmers followed the development of the virus in the infected larvae. Heavily infected larvae were placed in plastic bags and stored in the refrigerator.

Role of farm women in the CRSP sites with regards to pest management

Focus group discussion (FGD) with farmwomen in different sites in Nueva Ecija, Philippines was conducted. The FGD served as an initial assessment of the gender issues and of the roles of farm women in pest management. This activity will help refine the survey questionnaire to be used for future activities.

The FGD revealed that farmwomen are involved in pest management in rice-vegetable farming systems but are more active in vegetable crops. The farm women were also found to be knowledgeable about the proper use and effects of pesticides. However, farm women were more aware of the short-term or immediate effects of pesticides usage rather than on the long-term health impacts of pesticide poisoning. In addition, they have a few misconceptions about pesticide usage that needs to be corrected immediately to ensure their safety. The results of this study underscore the need for pest management extension services for farm women that address health and gender dimensions.

Mike Hammig comparing crops in Philppine experimental fields.

Farmer field schools (FFS) in N. Sumatra, Indonesia

During the period of May to October 2006, in Semangat Gunung and Doulu villages, 4 FFS groups of FFS were established which consisted of: FFS on Tomato (Lau Debuk-debuk Farmer Group) and FFS on Leek (Lau Tumekap Farmer Group) in Doulu village, and FFS on Tomato (Sibayak Simalem Farmer Group) and FFS on Leek (Kertah Ernala Farmer Group). Each group meets weekly to carry out field observations, agro-ecosystem analysis, presentation and discussions about the condition of the learning plots, decision making on what to do to manage the crop health (including pests), and planning for the next week's activity. In addition, they also learn about special topics and play games for group dynamics development. Basically, in each FFS the farmer group compared local practice treatment with IPM treatment determined by the group. Some groups also compared with ecological treatment learned from farmers from other locations.

The FFS on Tomato in Doulu has finished their season-long learning process and is preparing their plan for next season, while 3 other FFSs are still ongoing. During the FFS, the groups encountered some pests and diseases problems such as: *Phytophtora*, powdery mildew, and leafminer on tomato, and also aphids and "dry tip" on leeks. For managing those pests and diseases, the FFS groups tried to use botanical materials such as: lemon grass, *Piper betel*, gambir (kind of *Rubiaceae* plant), tithonia, citrus leaf, rotenone, neem, ingul (kind of neem), clove, citrus leaf and also sulphur.

Learning ecological principles and IPM

During the FFS, the farmers together with the farmer trainers learn about ecological principles, such as the plant growth, the relationship between the plant, insects, pathogens, natural enemies and micro-climates, soil ecology, soil nutrition and other related topics. Related to nutrition for soil microbes and plant, they learn to make compost, fermentation of manure, fermentation of fruit and also fermentation of urine (from goat or rabbit). They also learn on how to utilize botanical materials for managing pest and diseases.

Demonstration of IPM techniques to strawberry growers

Through on-farm experimental plots, farmers could observe for themselves the procedure for release of predatory mites and protocol following their release. On-farm plots allowed a farmer to compare results of his own conventional methods with those of the predatory mite releases. Results of weekly samples allowed the farmers to follow the progress and to understand what was occurring in the plot based on the numbers of spider mites and predatory mites collected each week. Comparison at the end of the six weeks allowed farmers to compare the economics of their spray regime with the monetary advantage of using predatory mites.

Five farmer cooperators were selected. A mini-demo plot was placed on each of the cooperating farms. Each farmer maintained his usual farming techniques outside the plot, while protecting each of the mini-demo plots from sprays. Each mini-demo plot consisted of approximately 20 plants. One hundred adult *A. longispinosus* were released once in each of the mini demos. Weekly samples from February to May and monthly samples from May were performed until the farmers tilled up the fields. Leaf samples were processed with a mite brushing machine to determine average numbers of spider mites and predatory mites inside and outside the demonstration plot. Within six weeks of the release, the numbers of spider mites in each demonstration plot had been reduced to zero while numbers of the predatory mites increased following a typical functional response. Outside the mini demo plots, spider mites were never reduced to zero within the same time period and evidence indicated the predatory mites would slowly disperse outward from the mini demo plot if the fields were not sprayed. *Amblyseuis longispinosus* was also found to be an effective control for the cyclamen mite, *Phytonemus pallidus*, which causes fruit damage and has been the primary pest problem during off-season production during the rainy season.

Seven IPM workshops and meetings with farmers were conducted. The IPM workshops included discussions on pests, methods of incorporating predatory mites into the current conventional systems and instruction in methods of identifying predatory mites and spider mites. Farmers were instructed in the proper use of a hand lens and live mite specimens were available for observation under a dissecting microscope.

A local radio station, DZWT 540 in Baguio City hosted us twice as guests on their farmer-call-in radio show. Each time we discussed the ongoing results of our experimental releases and answered questions and concerns by the farmers regarding the transition from a conventional approach to an IPM approach using predatory mites. We provided our cell phone number to the listening audience so that farmers could directly interact with us with any further questions regarding the use of predatory mites as well as pest problems affecting their crops.

Handling and release of predatory mites by farmers

Five cooperating farmers provided on site experimental plots for testing *A. longispinosus*. Farmers observed the handling and release of the predatory mites. The on-farm sites provided easy side-by-side comparison with their own conventional farming techniques. Weekly results of the samples provided the farmers with an understanding of the dynamics of a predator-prey system. This included aspects of the procedure, lag time and expectations from predatory mite releases.

Workshops

IPM communication and education in Southeast Asia

In August 2006 a workshop was held in Ciloto, West Java, Indonesia. Attendees included representatives of all the SE Asia IPM CRSP collaborating groups, as well as special guests, and representatives of the IT global theme. The main purpose of the workshop was to bring together collaborators to share experiences, plan for future activities, and to work out methods to maintain communications among the group to enhance our ability to learn from one another.

The workshop was an outstanding success in that, for the first time, all IPM CRSP collaborators from both countries were able to meet and interact professionally and personally. Information sharing was critical. Tangible outcomes include the beginning of testing in Indonesia of tomato grafting to eggplant rootstock to prevent soil borne diseases, especially in the wet season, which is a technology that has been successfully applied in the Philippines. The IT global theme will provide resources to organize a SE Asia IPM CRSP internet site to facilitate communications and continued sharing of IPM strategies for vegetables in the region..

Ecologically-Based Participatory and Collaborative Research and Capacity Building in IPM in the Central Asia Region

Karim Maredia, Michigan State University

The Collaborative Program

This project is designed to foster development of a comprehensive IPM initiative, using an ecologically based and multidisciplinary systems approach. Michigan State University, the University of California-Davis, and ICARDA serve as the host institutions for implementing this collaborative and participatory research-education program, designed to facilitate capacity building in IPM in Central Asia.

IPM Constraints Addressed

The countries of Central Asia are transitioning from centrally-planned monoculture agricultural systems to more diversified systems to meet the challenges of local food security, environmental quality, and natural resources management. Cotton remains a dominant crop in many of these countries, but the importance of food crops such as wheat, potato, tomato, and fruit crops in the region is growing to enhance local food security and shift from the former policy of monoculture agriculture. As a result, the participants of a forum held in 2005 identified a need to conduct research on the impact of agricultural diversification on local biodiversity and dynamics of pests and beneficial organisms. This information and knowledge would be useful when re-designing agroecosystems to conserve biodiversity and enhance biologically based pest management. The current emphasis of IPM programs in Central Asia is the augmentation through mass rearing and release of bio-control agents by a network of insectaries known as 'biolaboratories'. There are no programs that promote conservation of natural enemies and biodiversity in the agricultural landscape. Therefore, there is an opportunity to enhance IPM practices via landscape ecology and biodiversity.

Highly educated and well-trained human resources are available, however, research facilities and infrastructure need to be upgraded and modernized. For example, there are more than 800 biolaboratories in Uzbekistan alone that rear and provide bio-control agents to farmers. These laboratories have a narrow product line (4-5 species) and their efficiencies can be enhanced. These biolaboratories would also benefit from updated equipment and methodologies to improve their efficiencies. There is also a need to expand the laboratories' product lines to provide better services to farmers, address additional pests, and cover additional crops.

Although components of IPM programs are in place, there is a need to integrate these components into IPM packages and crop management programs. There is also a need for coordination among institutions and between countries to benefit from the already existing human resources and experiences. Communication and interaction with IPM specialists outside the region is lacking due to isolation, language barriers and limited financial resources. Therefore, there is need for collaborative projects and networking activities to foster interaction and exchange of knowledge and information.

In the absence of a formal government-run extension system, NGOs, farmer organizations and local universities are providing farmer training, technology transfer and outreach services. There is a lack of ecologically-based IPM approaches in these outreach and farmer training programs. IPM educational packages need to be developed that can be integrated into farmer field schools and other outreach programs.

Collaborative research on landscape ecology

A research fellow Dr. Nurali Saidov was given six weeks of training in landscape ecology by Dr. Douglas Landis at Michigan State University. Upon his return to Central Asia, Dr. Sadiov led teams of collaborators to collect Central Asian native plants for propagation and future field testing. The expedition in Tajikistan took place on 5-20 August, 2006 and included five scientists from, Tajik State National University, Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan and ICARDA. Participants covered 1200 km. of the Hissar and Khatlon regions and collected 32 local nectar plants (Table 1).

Table 1. List of plant species collected in Tajikistan, 2006

	Family	Genus and species	Common Name	Plant Type
1	Tamaricaceae	*Tamarix Sp.*	Tamarix	shrub
2	Rosaceae	*Rosa Sp.*	Dog rose	subshrub
3	Rosaceae	*Spirea Sp.*	Spirea	shrub
4	Lamiaceae (Labiatae)	*Origanum vulgare L.*	Oregano	forb
5	Lamiaceae (Labiatae)	*Ziziphora clinopodioides Lam.*	Interrupta	forb
6	Lamiaceae (Labiatae)	*Mentha sylvestris L.*	Horse mint	forb
7	Asteraceae (Compositae)	*Carthamus tinctorius L.*	Safflower	forb
8	Fabaceae(Papilionaceae)	*Glycyrrhiza glabra L.*	Licorice	forb
9	Malvaceae	*Alcea nudiflora (Lindle) Boiss.*	Alcea	forb
10	Liliaceae	*Eremurus Sp.*	Eremurus	forb
11	Alliaceae	*Allium Sp.*	Wild Allium	forb
12	Lamiaceae (Labiatae)	*Salvia deserta Schangin*	Clary sage, Europe sage	forb
13	Lamiaceae (Labiatae)	*Salvia officinalis L.*	Clary sage, Europe sage	forb
14	Malvaceae	*Althaea officina L.*	Althaea	forb
15	Asteraceae (Compositae)	*?ster novi-belgii L*	?ster	forb
16	Lamiaceae (Labiatae)	*Betonica foliosa Rupr.*	Betonica	forb
17	Onagraceae	*Epilobium hirsutum L.*	Epilobium	forb
18	Iridaceae	*Iris Sp.*	Iris	forb
19	Capparaceae (Capparidaceae)	*Capparis spinosa L.*	Caperberry, caperbush	shrub
20	Lamiaceae (Labiatae)	*Nepeta cataria L.*	Catnip	forb
21	Lamiaceae (Labiatae)	*Nepeta pannonica L.*	Catnip	forb
22	Lamiaceae (Labiatae)	*Hyssopus officinalis L.*	Hyssop	forb
23	Plantaginaceae (Scrophulariaceae)	*Linaria Sp.*	Linaria	forb
24	Asteraceae (Compositae)	*Echinops Sp.*	Echinops	forb
25	Lamiaceae (Labiatae)	*Leonurus turkestanicusV. Kreczetovicz & Kuprianova*	Leonurus	forb
26	Boraginaceae	*Echium vulgae*	Echium	forb
27	Lamiaceae (Labiatae)	*Thymus marchallianus Willd.*	Thymus	forb
28	Asteraceae (Compositae)	*Cychorium intybus L.*	Chicory	forb
29	Onagraceae	*Oenothera biensis L.*	Evening primrose	forb
30	Lamiaceae (Labiatae)	*Marrubium alternidens Rech.f.*	Marrubium	forb

The expedition in Kyrgyzstan included five scientists from the Botanical Research Institute of Academy of Sciences of Kyrgyz Republic and Bio-soil research Institute of Academy of Sciences of Kyrgyz Republic, and ICARDA. Participants covered 2000 km. of the Isiqkul, Talas and Jui regions and collected 30 local nectar plants (Table 2).

After the collection of these species, in collaboration with botanical and entomological researchers from the Tajik State National University and Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan, Dr Sadiov established research plots to test the attractiveness of 12 known and potential resource plants currently available in Central Asia (Table 3, Figure 1). A similar study was also initiated in Kyrgyzstan in 2006 with researchers from Botanical Research Institute of Academy of Sciences of Kyrgyz Republic and Bio-soil research Institute of Academy of Sciences of Kyrgyz Republic (Table 4). These initial tests revealed that *Anethum graveolens* L., *Coriandrum sativum* L., *Calendula officinalis* L., *Celosia cristata* L., *Foeniculum vulgare* Mill., *Impatiens balsamina* L. and *Ocimum basilicum* L. were the most attractive to insect natural enemies in the Tajikistan study and A. graveolens L., *C. sativum* L., *C. officinalis* L., *F. vulgare* Mill. and *O. basilicum* L. were most attractive in the Kyrgyzstan study. Representative natural enemy taxa collected at plants during bloom period in 2006 included: Vespidae, Sphecidae, Ichneumonidae, Braconidae, Chalcidoidea, Coccinellidae, Nabidae, Anthocoridae, Syrphidae (Figure 2) and Tachinidae.

Table 2. List of plant species collected in Kyrgyzstan, 2006.

	Family	Genus and species	Common Name	Plant Type
1	Tamaricaceae	*Tamarix arceuthoides Bunge*	Tamarix	shrub
2	Rosaceae	*Rosa canina L.*	Dog rose	subshrub
3	Lamiaceae (Labiatae)	*Origanum tyttanthum Gontsh.*	Oregano	forb
4	Lamiaceae (Labiatae)	*Ziziphora interrupta Juz.*	Interrupta	forb
5	Lamiaceae (Labiatae)	*Mentha asiatica Boriss.*	Horse mint	forb
6	Asteraceae (Compositae)	*Carthamus tinctorius L.*	Safflower	forb
7	Fabaceae(Papilionaceae)	*Glycyrrhiza glabra L.*	Licorice	forb
8	Malvaceae	*Alcea nudiflora (Lindle) Boiss.*	Alcea	forb
9	Apiaceae (Umbelliferae)	*Dacus carota L.*	Wild carrot	forb
10	Liliaceae	*Eremurus Olgae Rgl.*	Eremurus	forb
11	Alliaceae	*Allium rosenbachianum Regel*	Showy Onion	forb
12	Alliaceae	*Allium Sp.*	Wild Allium	forb
13	Lamiaceae (Labiatae)	*Salvia sclarea L.*	Clary sage, Europe sage	forb
14	Apiaceae (Umbelliferae)	*Conium maculatum L.*	Poison hemlock	forb
15	Scrophulariaceae	*Verbascum songaricum Schrenk*	Mullein	forb
16	Fabaceae (Leguminosae, Papilionaceae)	*Astragalus sieversianus Pall.*	Milk-vetch	forb
17	Fabaceae (Leguminosae)	*Onobrychis pulchella Schrenk*	Onobrychis	forb
18	Apiaceae (Umbelliferae)	*Prangos bucharica B. Fedtsch.*	Prangos	forb
19	Liliaceae	*Tulipa Sp.*	Tulip	forb
20	Capparaceae (Capparidaceae)	*Capparis spinosa L.*	Caperberry, caperbush	shrub
21	Boraginaceae	*Lindelofia macrostyla (Bunge) M. Popov*	Lindelofia	forb
22	Lamiaceae (Labiatae)	*Eremostachys alberti Regel*	Eremostach	forb
23	Asteraceae (Compositae)	*Pyrethrum parthenifolium Willd.*	Pyrethrum	forb
24	Asteraceae (Compositae)	*Achillea filipendulina Lam.*	Fernleaf yarrow	forb
25	Apiaceae (Umbelliferae)	*Elaeosticta hirtula Regel at Schmalh.*	Elaeosticta	forb
26	Campanulaceae	*Codonopsis clematidea (Schrenk) Clearke*	Asian bellflower	forb
27	Polygonaceae	*Polygonum coriarium Grig.*	Toron	forb
28	Apiaceae (Umbelliferae)	*Galagania fragrantissima Lipsky*	Shibit	forb
29	Guttiferae	*Hypericum scabrum L.*	Hypericum	forb
30	Fabaceae (Leguminosae)	*Lathyrus mulkak Lipsky*	Lathyrus	forb
31	Asteraceae (Compositae)	*Senecio renardii C. Winkl.*	Senecio	forb
32	Lamiaceae (Labiatae)	*Hyssopus seravschanicus (Dubjan)* Parij	Hyssop	forb

Table 3. List of plant species established at the research plot in Tajikistan, 2006

	Family	Genus and species	Common Name	Plant Type
1	Apiaceae (Umbelliferae)	*Anethum graveolens L.*	Dill	annual
2	Apiaceae (Umbelliferae)	*Coriandrum sativum L.*	Coriander	annual
3	Asteraceae (Compositae)	*Calendula officinalis L.*	Marigold	annual
4	Amaranthaceae	*Celosia cristata L.*	Cockscomb	forb
5	Asteraceae (Compositae)	*Tagetes erecta L.*	African marigold	annual
6	Apiaceae (Umbelliferae)	*Foeniculum vulgare Mill.*	Sweet fennel	forb
7	Balsaminaceae	*Impatiens balsamina L.*	Balsam	forb
8	Lamiaceae (Labiatae)	*Ziziphora interrupta Juz.*	Interrupta	forb
9	Asteraceae (Compositae)	*Aster Sp.*	Aster	forb
10	Amaranthaceae	*Celosia argentea L.*	Cockscomb	forb
11	Lamiaceae (Labiatae)	*Ocimum basilicum L.*	Sweet basil	forb
12	Asteraceae (Compositae)	*Helianthus annuus L.*	Common sunflower	forb

Improving efficiency and expansion of product lines in biolaboratories

Dr. Tashpulatova and Dr. Zalom have identified predatory mites of the family Phytoseiidae for the initial studies since these are not currently reared in Uzbekistan. The target range of these predatory mites includes spider mites, thrips and whiteflies. Dr. Tashpulatova visited UC Davis in May and June, 2006, to study identification, manipulation, and rearing of predatory mites in California, and to determine which Phytoseiid species might be most applicable to conditions in Central Asia. She visited several commercial insectaries rearing predatory mites, and fields to view predatory mite releases and sampling. It was determined that rearing methods used in California are not completely transferable to those in Central Asia because of the lack of availability of controlled conditions in environmental chambers or greenhouses necessary for mass-rearing some of the species. Preliminary studies were conducted at UC Davis to determine methods by which the predatory and prey mite colonies could be maintained.

Figure 1. Evaluating nectar source plants in test plots in Tajikistan

Table 4. List of plant species established at the research plot in Kyrgyzstan, 2006

	Family	Genus and species	Common Name	Plant Type
1	Apiaceae (Umbelliferae)	*Anethum graveolens L.*	Dill	annual
2	Apiaceae (Umbelliferae)	*Coriandrum sativum L.*	Coriander	annual
3	Asteraceae (Compositae)	*Calendula officinalis L.*	Marigold	annual
4	Asteraceae (Compositae)	*Tagetes erecta L.*	African marigold	annual
5	Apiaceae (Umbelliferae)	*Foeniculum vulgare Mill.*	Sweet fennel	forb
6	Solanaceae	*Petunia nana compacta*	Petunia	forb
7	Primulaceae	*Primula veris L.*	Primula	forb
8	Asteraceae (Compositae)	*Aster Sp.*	Aster	forb
9	Lamiaceae (Labiatae)	*Ocimum basilicum L.*	Sweet basil	forb
10	Asteraceae (Compositae)	*Helianthus annuus L.*	Common sunflower	forb

Inventory of IPM educational resources and directory of IPM specialists

Murat Aitmatov visited the laboratories of George Bird and Walter Pett at Michigan State University from June 1 through mid July 2006. At MSU, Murat Aitmatov developed a plan of work, budget, and evaluation metrics for the outreach/extension component. Dr. Aitmatov attended the MSU IPM short course from June 17-28, 2006. In addition, he visited the MSU Cooperative Extension offices in mid and southern Michigan, and had access to the MSU Library and their electronic databases.

After his return to Central Asia, Dr. Aitmatov has been working with partners in Tajikistan to develop electronic databases of all IPM consulting services and research organizations in the country. This database will be shared with all of the organizations in Central Asian countries for sharing of IPM information. In collaboration with Tajikistan Agrarian University, Dr. Aitmatov has been working to develop IPM training modules for training of trainers for FFS. This work resulted in Tajik agrarian university selecting six trainers - teachers from the Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan and Plant Protection and Quarantine Research Institute of Tajik Agricultural Academy of Sciences (TAAoS).

Figure 2. Beneficial syrphid fly on a test plant.

Training in agroecology, IPM and sustainable agriculture

Dr. N. Saidov, Dr. B. Tashpulatova, Dr. M. Aitmatov and Mrs. Inobat Avezmuratova, the Deputy Director of Winrock International office in Central Asia attended the Intenational Short Course on on Agroecology, Integrated Pest Management (IPM) and Sustainable Agriculture in June 2006. In December 2005, Inobat Avezmuratova visited the Advisory Training Center of the Rural Advisory Services (ATC-RAS) in Kyrgyzstan. The ATC-RAS is a specialized non-governmental organization focusing on implementing various activities on Integrated Production Management applying the Farmer Field School (FFS). The purpose of the trip was to build linkages and share knowledge with existing NGOs working in the area of FFS and training the trainers (TOT).

West Africa IPM Center of Excellence

Donald E. Mullins, Virginia Tech

The Collaborative Program

Co-Investigators on this project are Robert Gilbertson, University of California, Davis; Rick Foster, Purdue University; George Mbata, Fort Valley State University; Carlyle Brewster, Virginia Tech; Jean Cobb, Co-PI, Virginia Tech; Patricia Hipkins, Virginia Tech; and Jim Westwood, Co-PI, Virginia Tech. Amadou Diarra, Institut du Sahel (INSAH), is the Site Coordinator. Collaborating institutions are Agence Nationale de Conseil Agricole et Rural (ANCAR), Senegal; AVRDC: W. Africa/Global; CERES Locustox: Center of Research and Ecotoxicology of the Sahel (CERES)/ Locustox Foundation - Senegal; Direction de la Protection des Vegetau (DPV), Senegal; Environmental Toxicology and Quality Control Laboratory (ETQCL), Mali; Institute D'Economie Rurale (IER)- Mali; Int´l Institute of Tropical Agriculture (IITA), W. Africa/Global; l'institut de l'environnement et de recherches agricoles (INERA), Burkina Faso; Institut du Sahel (INSAH), W. Africa; The International Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP), W. Africa/Global; Institut de recherche agronomique de Guinée (IRAG), Guinea; Insitut Sénégalais de Recherches Agricoles (ISRA), Senegal; National Agricultural Research Institute (NARI), Senegal; L'Office de la Haute Vallée du Niger (OHVN), Mali; Programme de Développement de la Production Agricole au Mali (PRODEPAM), Mali; Réseau Africain de Développement de l'Horticulture (RADHORT), Senegal, W. Africa; SODEFITEX, Senegal; and Trade Mali, Mali. IPM CRSP Global Theme Projects that will collaborate in various activities with the West Africa IPM CRSP include: Information Technologies and Databases, Regional Diagnostic Laboratories, Insect Transmitted Viruses, and Impact Assessment.

IPM Constraints Addressed

The region comprising the nine West African CILSS (Comité Inter-Etate pour la Lutte contre la Sécheresse au Sahel) countries is well integrated when it comes to agricultural research and policy. However, extremely limited finances of key research and extension organizations, and a gap in donor-funded agricultural training, has resulted in suboptimal development of this region with respect to its potential for agricultural production. However, achievements of host country organizations, despite these circumstances, indicate that a well-organized IPM CRSP regional program can have substantial regional impact over a large area by coordinating and enhancing some of the research activities of the existing network of relationships. This project presents an investment plan for a strong collaboration of host country partners focused on research that will lead to improvements in the farmer's livelihoods of rural agricultural households and improving the environments in which people live. The Sahelian and Sudano-Guinean eco-zones extend through many CILSS countries, resulting in shared pest problems with a variety of crops. USAID has several country missions in CILSS countries, but it has also taken a regional approach through USAID West Africa. Previous IPM CRSP activities in West Africa have been limited to one country (Mali). This project expands research activities to Burkina Faso, The Gambia, Guinea and Senegal, resulting in a new regionally integrated program that reflects the expectation by USAID and the Management Entity that the new regional programs truly have regional impact.

Planning meeting

An on-site Participatory Planning Process (PPP) meeting was held in Kankan, Guinea on March 5-11, 2006, to discuss the project and to confirm the support for the research objectives among the participating countries (Senegal, Mali, Guinea, Burkina Faso, and the Gambia). Drs. Jim Westwood and Carlyle Brewster visited three of the participating countries (Senegal, Mali, and Burkina Faso) in September 2006 to work with local scientists to identify potential field sites for the whitefly research. The sites identified as most promising in Senegal included the cotton region at Kolda, the Niaye region, a predominantly vegetable-producing area near Dakar, and the Senegal River Valley, which is an area of large scale tomato production, with no cotton. In Mali, the most promising areas included the vegetable-growing area at Kati, the large-scale vegetable/rice area at Baguineda, an area of concentrated but small tomato fields, but no cotton at Mopti, and the cotton region at Sikasso.

Development of a website for the W. Africa Regional IPM project is ongoing. The site is developed as a content management system that will allow participants to enter information at any time and place to populate the site.

Regional workshop

A regional planning workshop was held at an agronomic research center in Bordo, Kankan, Guinea. Fourty-three researchers from West Africa and from American universities were in attendance. The objectives of the workshop were to determine and prioritize regional needs (key pests, crops, and sites) for study in years 3-5; linking people and agencies who may conduct parallel studies in different sites or cooperative studies involving several resources at one site; and, to initiate a process designed to gain a better perspective on regional crop production issues with interaction between the collaborating scientists.

Research Activities

Identification of viral diseases of tomato in West Africa

A sampling trip to observe symptoms of tomato diseases and to collect representative samples of tomato virus diseases was conducted in Mali, Burkina Faso, Ghana and Senegal. In all four countries, virus diseases of tomato were a major problem. The problem was particularly severe in Mali and Burkina Faso. The symptoms were typical of geminivirus infection and included leaf curl/crumple, stunting/distortion, yellowing and/or purple vein symptoms. Geminivirus infection was not detected in any weeds based on squash blot hybridization analysis, and this was whether or not virus symptoms were present. This is consistent with the hypothesis that tomato (and maybe pepper) are the major hosts of these viruses in these countries.

Inventory of weeds and associated tomato geminiviruses

Research. A database of common weeds of vegetable production in Burkina Faso, Mali, and Senegal has been assembled. This information is available in a searchable database on the project website. As part of this database, the role of the weed as a suspected or confirmed host of tomato geminivurus can be entered. This information has been added for some species based on literature of anecdotal evidence. Weeds on this list are: *Acanthospermum hispidum, Portulaca oleracea, Solanum nigrum, Sida* spp. and *Tribulus* spp. Efforts to confirm presence of virus in specific weed species have been initiated.

Capacity building. Westwood has met with collaborators, both at the organizational meeting in Kankan, and on a separate trip to Senegal, Mali, and Burkina Faso. The approach has been to synergize expertise within the individual countries and the region by linking researchers from different specialties (e.g., entomologists with weed scientists), different agencies (e.g., DPV with ISRA), and different countries.

Participatory appraisal in West Africa.

Participatory assessment of potato pests

Surveys of potato tuber moth were carried out in Senegal and Guinea. The potato cultivation areas of Senegal include the Naiye region that borders the Atlantic Ocean that lies between 15° 10’ 6.5’’ N and 16° 53’ 59.6” West. Potato tubers, flowers, and leaves were found to be severely attacked by the potato tuber moth (PTM), *Phthorimea opercullela*. The shoot of potato, particularly the leaves were found to be infected by bacterial wilt. Potatoes are cultivated in the middle and upper regions of Guinea. The PTM is the most important pest infesting all phenological stages of potato in Guinea. The PTM continues its infestation of potato tuber after harvest. The Senegalese team recorded a high incidence of PTM on other crops such as tomato and egg plants. These alternate crops could act as refugia for the moths when potato cultivation is out of season. The potato foliage and that of alternate crops were found to be diseased.

Pesticide safety education

Pesticide safety education (PSE) training programs for Mali and Senegal

In January and February 2006, we met with collaborators in Mali and Senegal and began to make plans for a PSE workshop for pesticide safety trainers in West Africa. Topics for discussion included potential sites, ideal dates, session content and length, teaching team members (who have program materials and methods to share), and invitees/participants. With their help and that of others/referrals, we continue to build lists of teaching team members and potential participants. Materials have beenobtained from some collaborators (e.g. Locustox, CropLife), and acquisition/review of appropriate tools and techniques continues.

Expansion of existing pesticide safety materials developed for Mali

Progress has been made in refining and expanding pesticide safety materials that have been developed for Mali. Activities have been directed towards reediting and refining ten lessons that include:

1. Introduction to Pesticides
2. Introduction to Pesticide Management – IPM
3. Pesticides and Risk
4. Pesticides and Toxicity
5. Pesticides and Exposure
6. Protective Clothing and Equipment: Who, When, Why and How
7. Tolerances for Pesticides in Food; and The Consequences of Pesticide Misuse
8. Applying Pesticides Safely and Effectively
9. Pesticide Poisoning and First Aid
10. Backpack Sprayer Calibration.

Production of an initial draft of two new lessons in English is underway and will complement the development of a nearly final draft of a bilingual booklet on IPM decision-making and technologies. This booklet will be produced and distributed during our West Africa safety training activities.

Meeting with pesticide residue chemists

Meetings with pesticide residue chemists were held in January/February 2006 at the LCV- ETQCL in Bamako, and then at CERES-Locustox in Dakar. Chemists at each institution emphasized the importance of method validation since only previously validated or in-house validated methods can be used if accredited to ISO 17025, the international benchmark needed to analyze fruits and vegetables for export. Based on these meetings, method validation was chosen as an inter-laboratory activity.

Workshop on quality assurance for pesticide residue chemists

A workshop was held from September 11-15, 2006 in Dakar, Senegal. The workshop agenda focused on planning for an inter-laboratory study, but included additional topics. Based on workshop discussions, CERES-Locustox agreed to validate the Quechers1 method for multi-residue pesticides in green beans (first priority) and mango and tomato (secondary priorities).

Integrated Pest Management of Specialty Crops In Eastern Europe

Douglas G. Pfeiffer, Virginia Tech

The Collaborative Program

The Eastern European Regional IPM CRSP project deals with several high-value horticultural crops: tomato, cucumber, grape and apple. The Collaborators in participating countries are Josef Tedeschini, Site Coordinator, Plant Protection Institute, Durrës, Albania; Vladimir Todirash, Site Coordinator, Institute for Plant Protection & Ecological Agriculture, Moldova; Olena Cholovska, Site Coordinator, Plant Protection Service, Lviv and Odesa, Ukraine; and Nicolay Kharytonov, Site Coordinator, Dnipropetrovsk State Agrarian University, Ukraine.

IPM Constraints Addressed

There are some unique constraints addressed in the Eastern European regional project. In the former socialist system, there was a small handful of individuals involved with farm decision making. In the current, post-privatization period, there is a very large population of new farmers - either new to agriculture, or at least new to farm decision-making. These farmers have little experience in farm operations, and furthermore, most have had almost no contact with university or government-based extension advice. Most information relating to pest management comes from pesticide or seed companies. Furthermore, there is a concern in some areas over sales of adulterated pesticides. This may be compounded by the more selective spectrum of activity of many newer pesticide classes, possibly resulting in decreased apparent control if used improperly. In order for the Eastern European countries involved to recapture their former role as producers of high quality horticultural crops, significant progress must be made in modernizing IPM practices, and improving technology transfer.

Participatory Appraisal

The Participatory Appraisal was conducted in Ukraine and Moldova, for tomatoes and cucumbers. Americans on the PA team were Doug Pfeiffer, Tony Bratsch (Virginia Tech), Sally Miller (Ohio State University), and Milt McGiffen (Univ. California Riverside). Ukrainian team members were: Olena Cholovska (L'viv Oblast Plant Protection Service), Gala Shestopal (L'viv Commercial Academy), Myroslava Ishchuk (L'viv National polytechnic University), Nicolay Kharytonov, Kateryna Maslikova (Dnipropetrovsk State Agrarian University), and Oleksandr Pleshko (Odesa) and Oleksandr Pleshko (Odessa Oblast Plant Protection Service. Moldovan team members were Vladimir Todirash and Tatiana Tretiakov (Institute for Plant Protection & Ecological Agriculture (Chisinau)). The team visited 21 sites for stakeholder interviews; these consisted mainly of farms but with a few research facilities included. Farmer issues included a lack of experience since many are new farmers, becoming involved in agriculture after the privatization period, a lack of education and sources of impartial advice. Most have no experience with extension personnel, and obtain most of their information from pesticide and seed companies. There are therefore problems with basic identification and management of insects and diseases. Problems of researchers involve mainly lack of resources to (1) conduct research, (2) travel to farms for technology transfer, and (3) obtain training abroad.

Baseline Survey

The baseline survey in all countries was started in the latter part of the year. Farm visits and interviews have been completed in Moldova and are underway in Ukraine and Albania. This survey will allow a more quantitative assessment of current practices than provided during the PA, and will allow a gender analysis.

IPM Activities in Tomatoes and Cucumber

Planning was made regarding specific experiments. Collaborations were initiated on sharing insect natural enemies produced in Moldova with partners in Ukraine. Determinations of late blight races and resistance status in Ukraine will be a focus.

Technology Transfer

Language translation

Breeze presentations created and posted in Eastern European IPM CRSP web site (http://everest.ento.vt.edu/Fruitfiles/Albania/EasternEuropeIndex.html) (a shorter, more intuitive URL has been applied for and should be approved and working soon: http://www.eeipmcrsp.shorturl.com). One presentation discusses an economic analysis of the first phase of the project, in English and Albanian:

http://breeze.ag.vt.edu/p98117832/
http://breeze.ag.vt.edu/p92937780/

The second presents an overview of the second phase of the project, posted in English and Ukrainian. The Ukrainian version was divided into two segments to overcome technical problems in uploading large files from Ukraine
http://breeze.ag.vt.edu/p76576144/
http://breeze.ag.vt.edu/eeipmcrspukraine/
http://breeze.ag.vt.edu/eeipmcrspukraine2/


Discussing IPM with Albanian farmer.

Albania
Several publications disseminating IPM CRPS results was produced and distributed:

Ukraine - L'viv
Two publications promoting IPM practices in fruit crops are in development: "Intensive Technology of Soft Fruit Production" - Gala Shestopal and Douglas G. Pfeiffer.

A workshop was held on 12-13 September on the farms "Lesi Yukhym" (v. Sknyliv) and of Zolochiv Agricultural College (v. Novoselyshcha of Zolochiv district) "Monitoring of the development of insects and diseases" and "Prospects of an integrated plant protection system and organic agriculture". Apples and cucumbers were given special attention. The target audience: farmers, college instructors, plant protection workers and non-governmental organizations. 60 persons participated.

A meeting-workshop was held on 2 November 2006 with the plant protection specialists (50 participants). The topic was "Autumn monitoring of agricultural plots to determine insects populations and disease infestation in order to forecast their development in the coming year", planning protection measures for the next year, including chemical measures".

Ukraine - Dnipropetrovsk
Publications
Maslikova, K., M. Kharytonov and O. Lazareva. Tomato diseases and plant protection approaches. Agroview magazine, p.10-16, 2005, 26 Dec 2005 (in Ukrainian)

Kharytonov, M. co-authored the following recommendations: Biological preparations and their effective application for vegetable and melon. Kiev, 2005 -12 p. (in Ukrainian)

Training
Kharytonov and Maslikova took part as volunteers in two training courses on tomato growing to teach unemployed individuals - invited by Dnipropetrovsk, Occupation Center and Dnipropetrovsk State Agrarian University Extension Center in September 2006. One hundred unemployed individuals received instruction.

Management of the Weed Parthenium (Parthenium hysterophorus L.) in Eastern and Southern Africa Using Integrated Cultural and Biological Measures

Wondi Mersie, Virginia State University

Collaborators

Amhara Micro-enterprise development, Agricultural Research, Extension and Watershed Management (AMAREW) Project, VirginiaTech; Department of Crop and Soil Environmental Sciences, Virginia Tech; Haramaya University, Dire Dawa, Ethiopia; Amhara Regional Agricultural Research Institute, Bahir Dar, Ethiopia; Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia; Mekele University, Ethiopia; Save the Children UK, Addis Ababa, Ethiopia; Agricultural Research Council, Plant Protection Research Institute, Hilton, South Africa; Department of Agricultural Research, Gaborone, Botswana; Makerere University, Kampala, Uganda; CAB International, Africa Regional Center, Nairobi, Kenya; International Maize and Wheat Improvement Center, Addis Ababa, Ethiopia; IUCN, World Conservation Union, Nairobi, Kenya; International Institute of Tropical Agriculture, Catnou, Benin; The University of Queensland, Brisbane, Australia; and Indian Agricultural Research Institute, New Delhi, India.

IPM Constraints Addressed

Parthenium (*Parthenium hysterophorus* L.) (Asteraceae) is an invasive weed species found in eastern and southern Africa. It is a native of sub-tropical areas of South and North America. The lightness of the seed, prolific seed production, adaptability to a wide range of habitats, drought tolerance, ability to release toxic chemicals against other plants, and high growth rate allows it to colonize new areas quickly and extensively. In eastern and southern Africa, parthenium reduces the yield of all major crops and competes with preferred pasture species; and when consumed by domestic animals it taints their milk and meat and reduces their value. It also causes many human health problems such as severe contact dermatitis and respiratory problems. In addition, because of its allelopathic properties, parthenium replaces natural vegetation and thus it is a threat to one of the world's richest regions of biodiversity, eastern Africa. The protection of this biodiversity is in the interest of the U.S. because these threatened plants could be sources of valuable medicinal or industrial compounds. Parthenium in African small scale subsistence farming is currently controlled by hand weeding and this task is primarily done by women as well as school-age children. So any management system that can control parthenium will reduce the workload on women and school-age children to allow them engage in other productive activities. Despite its aggressiveness, parthenium is successfully managed in Australia and India using biological agents such as insects, pathogens and smothering plant species; similar work has also begun in South Africa. The goal of this project is to develop an integrated weed management system that reduces the adverse impact of parthenium on humans, crops, livestock, and plant biodiversity in the regions of eastern and southern Africa.

Workshop on parthenium in Addis Ababa, Ethiopia

A meeting of all project participants was held in Addis Ababa, Ethiopia on December 12 to 16, 2005. A total of thirty people from Australia, Benin (IITA), Botswana, Ethiopia, Kenya (CABI), India and South Africa attended this five-day meeting. The goal of the workshop was to develop a detailed plan and methodologies for implementation of the IPM CRSP parthenium project. The specific objectives for the workshop were to:

1. Discuss and develop a common protocol for the implementation of each objective.
2. Obtain knowledge of methodologies for parthenium survey, socio-economic and biodiversity impact data collection, biocontrol agent evaluation and pasture trials.
3. Familiarize project partners with IPM CRSP and USAID regulations, expectations, and monitoring and evaluation procedures.
4. Develop strategies for dissemination of results.

Main topics of presentations were on distribution of parthenium in eastern and southern Africa; its impact on socio-economics, plant diversity and development of a biocontrol program in Ethiopia; evaluation and release of biocontrol agents in South Africa and Ethiopia; and evaluation of pasture management systems in Ethiopia.

Collaborators discussed and developed protocols for each objective. Participants were trained on methods of parthenium survey, evaluating its impact on people, and plant biodiversity. The facility at the EIAR Plant Protection Research Center was visited and recommendations for upgrading it to enable importation and research on imported biocontrol insect agents were provided. A working plan was developed by project participants for all activities and outputs for the project. The workshop also gave an opportunity to the project partners from various countries to meet, interact and discuss topics relating to the control of parthenium.

Figure 1.Examination of parthenium in the field.

Research Activities

Survey of parthenium in Eastern and Southern Africa

A survey of parthenium in Ethiopia and Uganda was completed. In Botswana, parthenium was not found in the areas surveyed. To conduct surveys in South Africa and Swaziland, CLIMEX model parameters were obtained from the Queensland Department of Natural Resources and Mines (QDNR&M), Australia. The parameters were entered into a new species template in the CLIMEX program (ver. 2) and the model was run. Predictive maps for southern and eastern Africa were generated (Fig. 1). The maps depict the Ecoclimatic Index (EI) i.e. an index showing the climatic suitability of a particular area for the favourable growth of parthenium. These maps were used to assist in the formulation of the survey strategy for South Africa, Swaziland, Botswana, Uganda and Ethiopia.

Baseline distribution and roadside survey: In order to determine the current distribution of parthenium in South Africa and Swaziland, the South African Plant Invaders Atlas (SAPIA) database and Swaziland's Alien Plant database (http://www.kbraunweb.com/alienplants/speciesinfo.asp) were utilised to obtain baseline information on the distribution of parthenium in South Africa and Swaziland. Baseline distribution maps were plotted using the programme MAPPIT at the quarter degree square (QDS) scale using these data.

A road survey route around each known distribution QDS was conducted in South Africa and Swaziland between 02/28/2006 and 03/03/2006 and on 03/09/2006, to determine whether parthenium occurred in the QDS immediately surrounding the known distribution QDS (Fig. 1). A maximum of eight QDS immediately adjacent to each known distribution QDS were sampled. The survey was conducted at the end of the summer growth season when plants were in full flower and easily identifiable. In QDS where parthenium was observed and had not been previously recorded, the following data were recorded: date, coordinates, altitude, locality name, description of infestation (e.g. patchy, roadside, cultivated fields). The abundance of parthenium at each site was recorded as either low (1 plant/m^2), medium (2-3 plants/m^2) or high (>3 plants/m^2). At some sites, leaf samples were taken for future DNA analysis and photographs were taken. Locality data were plotted using the programme MAPPIT.

CLIMEX model predictions indicated that there were areas of Ethiopia, Kenya, Somalia, Tanzania and Uganda that were ecoclimatically suitable for the favourable growth of parthenium (Fig. 2). However, the strength of the model predictions were limited (for example Ethiopia and Somalia) where there is access to weather station data. Predicted areas most suitable for the growth of parthenium were largely to be found in Kenya (e.g. Kisumu, Nairobi, Tika, Marsabit, Moyale), Somalia (e.g. Mogadiscio), Tanzania (e.g. Dar es Salam, Same, Kisauni) and Uganda (e.g. Mbarara, Jinja, Tororo). In Ethiopia: Nagele, Kembolcha and Harar were considered marginally suitable for the optimal growth of parthenium.

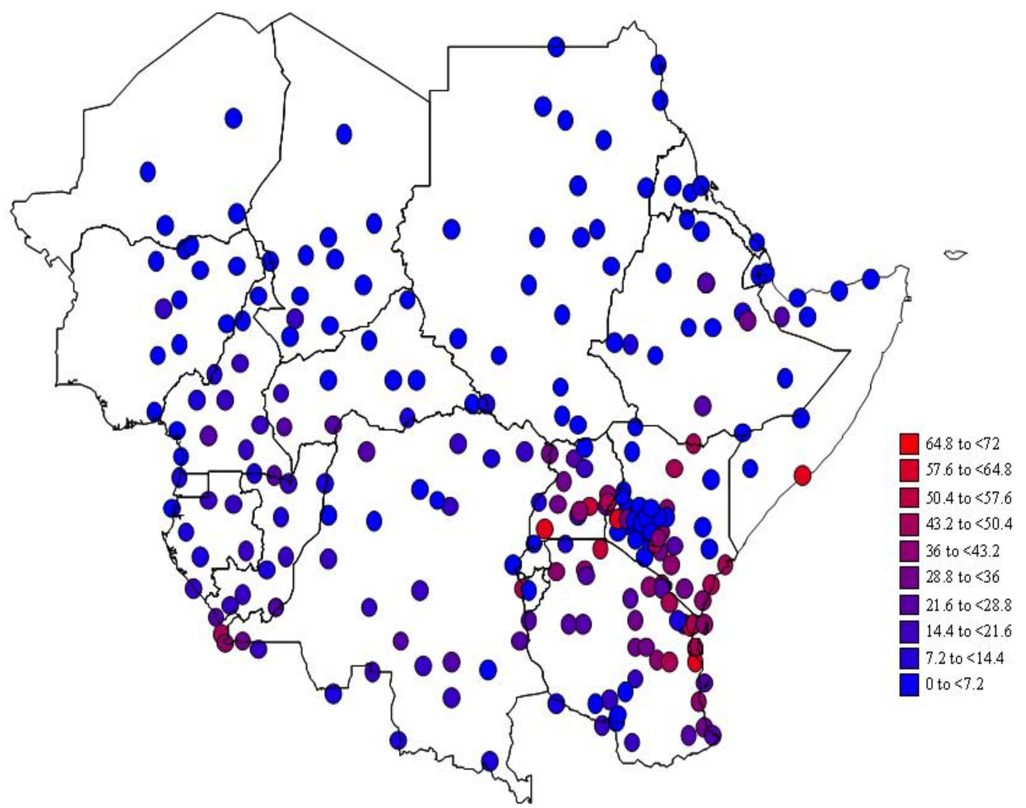

Figure 2. CLIMEX generated map of the relative climatic suitability of eastern Africa for parthenium. Colours of the circles (ecoclimatic index) depict the suitability of each location (red - more suitable, blue – less suitable).

For southern Africa, the CLIMEX model predicted that areas most suitable for the favourable growth of the weed were to be found in South Africa (e.g. along the east coast), Swaziland (e.g. Wissellrode) and Mozambique (e.g. Maputo, Quissico, Inhambane, Vilanculos) (Fig. 3). As with certain countries in eastern Africa, the predictive strength of the model was affected by limited weather station data for Namibia and Botswana. However, as was evident from the model predictions for Zimbabwe - Namibia and Botswana were shown to be relatively unsuitable for the favourable growth of parthenium.

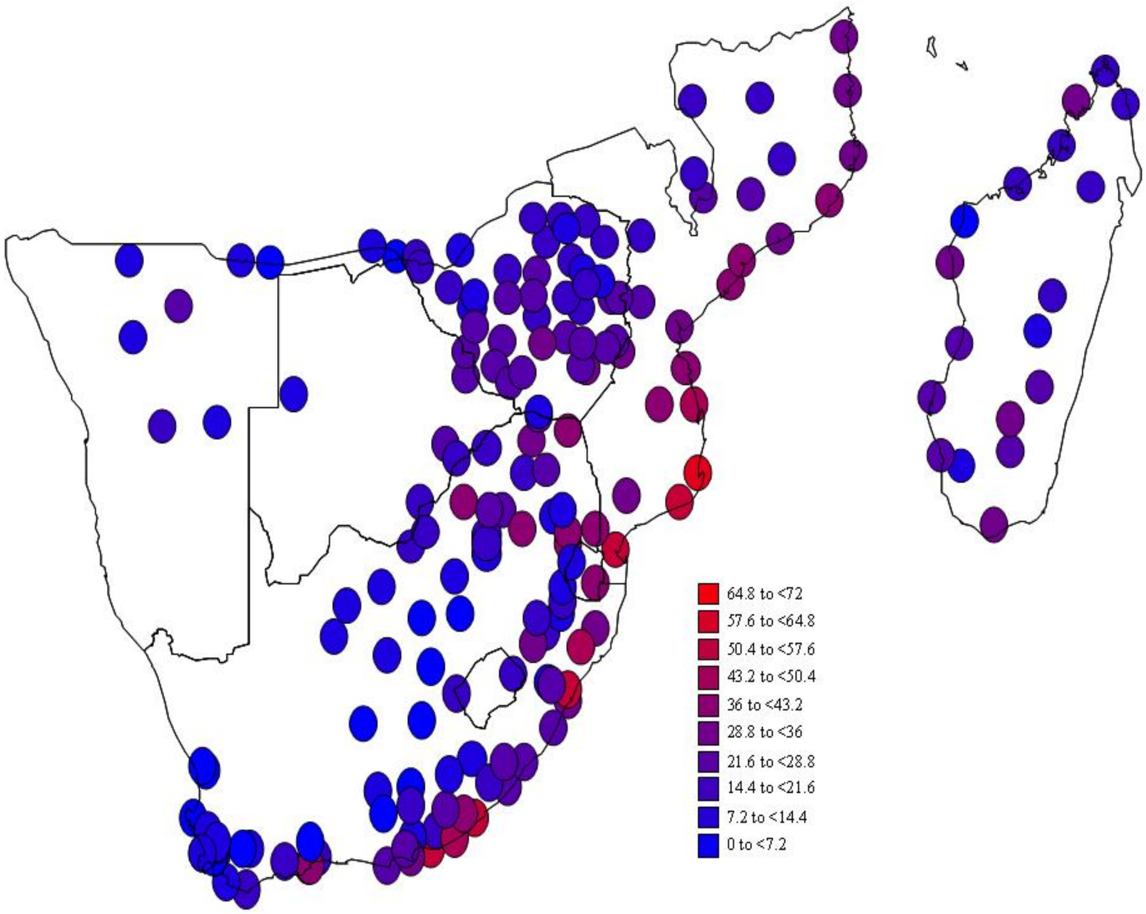

Figure 3. CLIMEX generated map of the relative climatic suitability of southern Africa for parthenium. Colours of the circles (ecoclimatic index) depict the suitability of each location (red - more suitable, blue – less suitable).

Baseline distribution & Survey: Using SAPIA and Swaziland's Alien Plant Invader Database, parthenium was found to have a baseline distribution of 44 quarter degree squares prior to February / March 2006. With the conclusion of the roadside survey, however, parthenium was found to occur in an additional 26 quarter degree squares. Infestations were largely located in disturbed areas - mainly roadside, fallow fields, vacant land in towns, etc. Abundance of these populations was for the most part rated as high.

The distribution of parthenium in South Africa appears to be mainly along the eastern parts of the KwaZulu Natal province, extending into the northeastern and western reaches of the Mpumalanga province, and northeastern parts of the North West province (Fig. 4). In Swaziland, the weed was found to occur in almost every quarter degree square throughout the country.

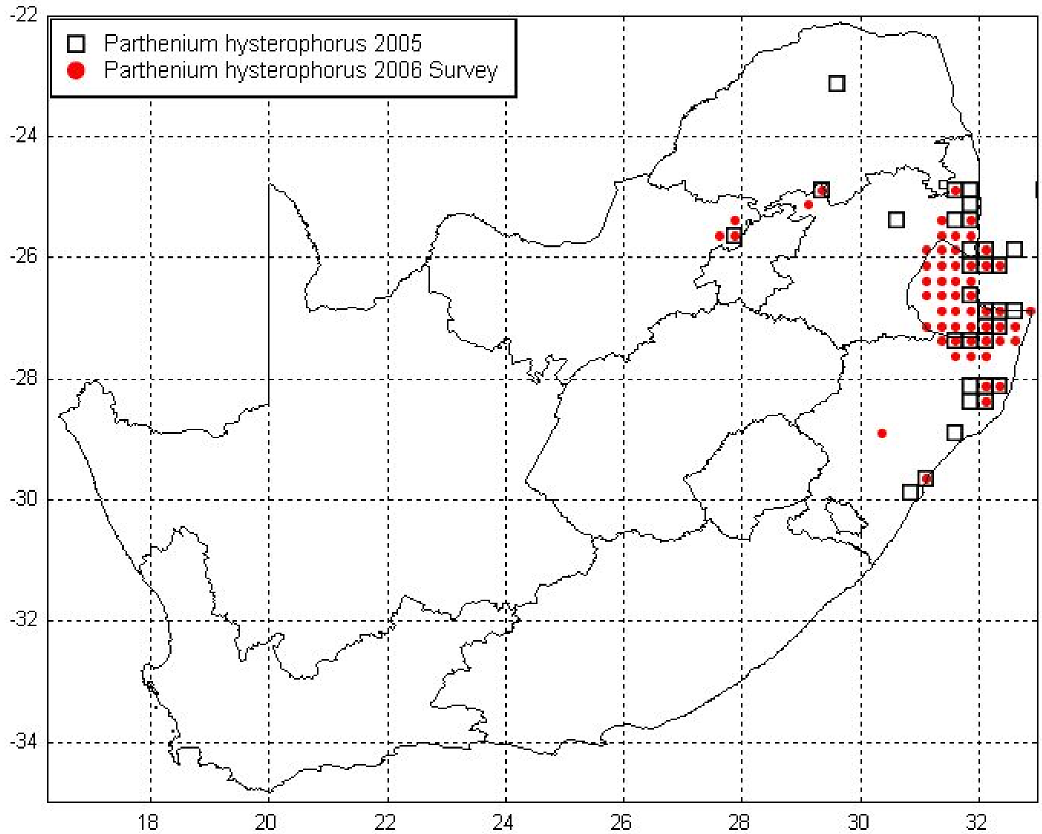

Figure 4: Distribution map of parthenium in South Africa, Swaziland and part of Mozambique, with previously known records from SAPIA and Swaziland Alien Plant Database (black squares) and distribution records in new quarter degree squares from 2006 survey (red dots).

Discussion: From the roadside survey conducted in February and March 2006, it was evident that parthenium is much more widely distributed in parts of South Africa and Swaziland than was previously known. Parthenium was recorded in 26 QDS in South Africa and Swaziland where it had not previously been recorded. This cannot be solely accounted for by an increase in spread, but could also be attributed to an increase in sampling effort. At many sites not previously known, parthenium abundance was recorded as high and infestations were dense and large. Due to time constraints and limited access roads, only the QDS immediately surrounding the previously recorded distribution were sampled during this current survey.

This species-specific survey of distribution was beneficial for the following reasons: (i) it increased knowledge of the current distribution of parthenium, and indicated parthenium to be more widely spread than previously known, (ii) it provided baseline data to monitor spread and abundance of parthenium in the future, both with regard to the presence of the plant and ultimately as a rough measure of the impact of biocontrol agents once released and established, and (iii) it provided locality information on the severity of parthenium infestations which will be useful in selecting the most suitable sites for release of biocontrol agents when available.

Biocontrol Quarantine Facilities in Ethiopia

The process of upgrading the glasshouse facilities at EIAR, Ambo in Ethiopia to a quarantine facility suitable for conducting pre-release evaluation on insect biocontrol agents for parthenium control have been started. A site visit to the research facilities at EIAR at Ambo was conducted during the Partners Planning workshop in December 2005. The glasshouses, laboratory and proposed plant growing area were inspected. Suggestions were made for modifications to the glasshouse facility to enable quarantine research to be conducted on parthenium insect agents. Diagrams of the designs of insect rearing and testing cages, chlorine traps, light traps, glasshouse emergency cooling system, and suggested modifications to the Ambo facility were also provided. Samples of material recommended for glasshouse shading and material for insect cages were also provided for sourcing locally. Based on the recommendations, EIAR has made extensive modification to the quarantine facility.

Evaluation of safety of biological control agents

Insect and plant culturing: Healthy plants are required for culturing and testing of insect agents. Plants are kept free of diseases, pests, and predators. Several lots of 100 parthenium plants at different stages of development are required, with continual planting for constant turnover of plants. Once parthenium plants have been used in insect cultures they cannot be re-used, so a constant supply of appropriately-sized plants is required. A sand and mushroom compost mixture (1:2 or 1:1) is used for parthenium plants. Different insect agents require different sizes of plants e.g. *Listronotus setosipennis* requires plants with flowers and robust stems; *Zygogramma bicolorata* requires plants with leafy foliage.

Insects are reared in a quarantine laboratory maintained at 24-30 ºC and 70% relative humidity, and a 12h:12h light regime. Foliage and cages are lightly sprayed with water daily using an atomizer to provide free water for insects. Insects are housed in gauze-sided cages of about 0.5 m x 0.5 m x 1.0 m with plants of appropriate size. Insect density in cages varies, depending on species. Adults (and larvae of *Z. bicolorata*) are transferred to new plants for feeding and ovipostion about every 2-3 weeks. All used material from quarantine is disposed of by freezing for 48 hours before removal from quarantine for incineration.

Host-specificity testing: Extensive host range testing has been conducted in Australia and India on selected biocontrol insect agents for parthenium. Using the information already known about the host range of each agent, a list of indigenous, economically important crop and ornamental species can be drafted particular to each country or region. Initially no-choice tests (where insects are given no alternative host plant) are being used to narrow the range of plants that are able to support oviposition and larval development. Thereafter, single-choice tests (where parthenium and a test plant are available to the insects) will be used if there is development on non-target species in no-choice tests, to determine if there is a preference. Plants with similar above-ground biomass are used and a control is included for every trial. Each plant species is replicated three times, and variables such as oviposition, feeding, development, and survival are measured. Ten adult *L. setosipennis* or 10 pairs of *Z. bicolorata* adults are exposed to single plants of either control or test plants for five or 10 days, respectively. For *L. setosipennis* progeny survival is used as a measure of host suitability, and for *Z. bicolorata* adult feeding and quantity of eggs produced is used as the indicator of host suitability in initial no-choice tests.

Rearing of insect biocontrol agents

Plants: At least 500 parthenium stock plants were maintained on a regular basis to ensure sufficient plants for rearing of insect agents. Selected test plant species of commercial, indigenous, and externtal origin to be used in host range tests were also obtained and maintained.

Insect agents: Cultures of *Zygogramma bicolorata* (Coleoptera: Chrysomelidae) and *Listronotus setosipennis* (Coleoptera: Curculionidae) that had earlier been imported from Australia and Argentina respectively, were maintained in the PPRI quarantine laboratory at Cedara, Hilton during the reporting period. Routine maintenance of cultures was carried out on a daily basis, providing cultures with a clean environment, and sufficient food and oviposition sites.

Host range testing of biocontrol agents: While there will be some overlap of species that are tested in South Africa and Ethiopia, there are plant species and varieties that are unique and relevant to each region; and that need to be tested in host range trials of biocontrol agents. These plants will not be duplicated in nor are they relevant to the other country or region. Therefore, a different test plant list has been drawn up for each country. South Africa and Ethiopia will each test plants that are relevant to their regions and governing authorities. Nevertheless, following a decision at the Partners Planning Workshop in Addis Ababa, Ethiopia in December 2005, PPRI is to test selected parthenium biocontrol agents on the two most important crops in Ethiopia, *Guizotia abyssinica* (noog) and *Eragrostis tef* (teff), before the biocontrol agents are exported to Ethiopian quarantine for further host range research there. Accordingly, applications for importation of *G. abyssinica* (noog) and *E. tef* (teff) seeds into South Africa were submitted to the South African Department of Agriculture, Directorate Plant Health in January 2006; importation permits for seeds of these species were received in April 2006.

No-choice host range tests were designed and initiated during the reporting period, and a single replicate of several test plant species was run separately for *L. setosipennis* (Table 1) and *Z. bicolorata* (Table 2).

Table 1: Preliminary results of one replicate of no-choice tests with *Listronotus setosipennis*. 0 = no adult progeny, * = F1 adults produced.

Test plant		Adult progeny production
Tribe	**Species**	
Asteraceae: Asteroideae		
Heliantheae	*Parthenium hysterophorus*	*
	H.annuus AGSUN 825	0
	H. annuus PAN 7392	0
Eupatorieae	*Adenostemma caffrum*	0
	Mikania natalensis	0
Anthemidae	*Argyranthemum frutescens*	0
Astereae	*Aster novi-belgii*	0
Asteraceae: Cichoriodeae		
Arctoteae	*Arctotis arctotoides*	0
Vernonieae	*Ethulia conyzoides* subsp. *kraussii*	0
Lactucaceae	*Cichorium intybus*	0

Table 2: Preliminary results of oviposition and feeding from one replicate of no-choice tests with *Zygogramma bicolorata*.

Test plant		Total no. eggs & larvae	Feeding %
Tribe	**Species**		
Asteraceae: Asteroideae			
Heliantheae	*Parthenium hysterophorus*	498	>85
	H.annuus HYSUN 345	0	2-10
Eupatorieae	*Adenostemma caffrum*	0	0
	Mikania natalensis	0	3
	Mikania capensis	0	2
	Ageratina riparia	0	0
	Campuloclinium macrocephalum	35	3.5
Asteraceae: Cichoriodeae			
Arctoteae	*Arctotheca capensis*	0	0

Stock and test plants and cultures of *L. setosipennis* and *Z. bicolorata* were obtained and increased during the reporting period. The outbreak of the pathogen *Beauveria bassiana* hampered productivity by diminishing the culture size and availability of insects for host range testing. However, this problem was overcome and cultures have been increased in size in preparation for further research in 2006-2007. Although still too early to predict, preliminary results of host range testing of *L. setosipennis* and *Z. bicolorata* on selected indigenous and plant species economically important to South Africa indicate a narrow host range. Further replicates on these species as well as tests on other indigenous, ornamental and economically important Asteraceae, particularly in the tribe Heliantheae in which parthenium occurs, will be conducted during the next year of the project to determine the suitability of each agent for release in South Africa.

Soil seed bank of parthenium and plant diversity in parthenium infested areas

In preparation for the future time when the impact of approved, released and established biocontrol agents can be assessed in the field, trials were conducted to obtain baseline data on the extent of local soil seed banks of parthenium and relative composition of other plant species within parthenium infested areas of national biodiversity conservation significance.

In April 2006, at the end of the summer growing season, three sites with large parthenium infestations were selected within an area of national conservation significance, Kruger National Park in Mpumalanga Province. At each site, an area of 35-40 m^2 within the dense infestation of parthenium was selected and demarcated and 20 quadrats of 0.5 x 0.5 m = 0.25 m^2 were randomly selected. The coordinates of each area were recorded so that these same areas at each site can be monitored in the future for comparison of parthenium seed banks before and after release of biocontrol agents. The number of mature parthenium plants within each quadrat was recorded as a measure of plant density. Using a soil corer (7 cm diameter x 6 cm deep), five soil cores were removed from each quadrat (four from each corner and one from the centre of the quadrat). Soil samples were combined per quadrat and removed to the laboratory for further studies.

In the laboratory at PPRI, Cedara, a 5 cm layer of sterilised potting soil was placed in each of 80 seedling trays (30 cm x 27 cm x 11 cm) (20 samples per site, and 20 samples as a control). Each soil sample was then spread onto the sterilised potting soil of the seedling tray and seedling trays were placed on low, well draining tables in a temperature-controlled tunnel for four months. After four months, the soil was turned and the experiment conducted for a further month. Soil was watered daily and the numbers of parthenium seedlings and seedlings of other plant species that germinated were recorded regularly. Germinated parthenium seedlings were removed from seedling trays as soon as they were identifiable. Seedlings of other plant species were removed and potted individually or in small groups and grown until flowering stage. Herbarium specimens of each were then taken for identification. Similar trials will be repeated annually or as required in order to ultimately assess the impact of biocontrol agents on parthenium soil seed banks at these sites.

Table 3: Preliminary results of *parthenium* plant density at three sites in Kruger National Park and soil seed bank after one month of seedling germination.

Site	Mean no. of plants/m^2 ± s.d.	Mean no. of parthenium seedlings/m^2
1	27.8 ± 27.5	21694.7 ± 9674.7
2	172.8 ± 67.4	72928.9 ± 28047.1
3	76.6 ± 52.4	32943.5 ± 17053.8
Mean	92.4 ± 79.2	42522.4 ± 29473.5

Large numbers of mature parthenium plants per m^2 were counted within parthenium infestations in Kruger National Park at the end of the summer season (Table 3). Although this trial is still underway, early indications are of a large soil seed bank, with a mean of about 43,000 seedlings per m^2 germinating within the first month, and a maximum of about 73,000 seedlings per m^2 germinating within one month of collection from one of the sites. This trial is still underway so it is too early to provide complete results. These figures will be much higher for the entire duration of the trial, and data are still being collected on the relative composition of parthenium and other plant species within the infestations. These data will be most beneficial to provide a baseline of parthenium soil seed bank without biocontrol agents available, to ultimately determine the impact of the biocontrol agents on parthenium at selected sites, once agents have been approved, released and established in the field. It is expected that *L. setosipennis* and *Z. bicolorata* will impact existing stands of parthenium by directly and indirectly reducing the quantity of seeds available for re-infestation. It is predicted therefore that the biocontrol agents may impact current infestations of parthenium as well as limit spread of the weed.

Pasture Management for the Control of Parthenium

The study site is located 30 km east of Jijiga (09°12’ 33.4’’ N, 034°04’ 03.7’’E, at an elevation of 1640 m) at Hare II Research Site of Jijiga Agricultural Research Center in eastern Ethiopia. The area was heavily infested with parthenium and has not been plowed for the past five years. The vegetative composition of the site was identified and the percentage of cover of the major species estimated. Soil samples were taken from 1 to 30 cm depth for analysis.

The experiment consisted of the following treatments:

1. Mowing+Oversowing of selected forage species
2. Burning+Oversowing of selected forage species
3. Burning alone
4. Control (undisturbed vegetation)

Each main plot; i.e, mowing or burning; was 39 m long and 5 m wide and replicated three times.

The following forage species were selected for over sowing based on EIAR’s and the International Livestock Research Institute’s recommendation for their adaptability to the area and competitive ability:

1. *Chloris gayana*

2. *Chamaecrista rotundifolia*
3. *Desmanthus virgatus*
4. *Macrotyloma axillare*
5. *Neonotonia wightii*
6. *Stylosanthes hamata*
7. *Stylosanthes scabra*

Chloris gayana is a tropical grass and the rest are all tropical legumes. The seeding rate is 10 kg/h for all species. This rate is twice the normal seeding rate used in conventional seeding. The seeds were hand broadcast and the plots were disturbed with sticks to improve the chance of seed-soil contact. The plot size of each of the over sown species was 4 m by 5 m. The sowing date was July 14, 2006.

Seedling population of the over sown forage grass and legume species will be determined using 0.25 m^2 quadrats, 6-8 weeks after seeding. Botanical composition and dry matter yield will be determined after the establishment of the oversown species

Regional Diagnostic Laboratories

Sally Miller, Ohio State University

The Collaborative Program

Our efforts are focused on development of plant disease diagnostic capacity in three critical regions: West Africa, East Africa and Central America/Caribbean. Our project will be closely linked to IPM CRSP regional programs and other Global Theme programs in selected countries by sharing resources and scientists and by developing joint research programs. Collaborating U.S. institutions in this efffort are The Ohio State University, Virginia Tech, the University of Florida, The University of California-Davis, and the University of Wisconsin. Faculty from each institution participate in at least one "Operation Comittee" for a regional diagnostic site, providing assistance to the sites including expertise and training. In addition, participants from these institutions provide specific inputs into program areas. The Ohio State University is the lead institution, provides leadership for the program, and is developing diagnostic assays under Objective 4. The University of Florida is responsible for development of the Digital Distance Diagnosis and Clinic Information Management System. Virginia Tech and the University of California-Davis provide expertise in virus diagnostics, assay development and linkages with the Insect-Transmitted Viruses Global Theme. Host country institutions are responsible for implementation of the regional networks and development of diseases diagnostic capacity through infrastructure support and training. These institutions are 1) Agroexpertos, Guatemala; 2) IITA, Benin; and 3) Kenyan Agricultural Research Institute (KARI), Nairobi/AVRDC, Tanzania.

IPM Constraints Addressed

Plant diseases cause significant economic losses throughout the world, but their effects are felt most severely in developing regions, where the majority of families obtain their livelihood from farming. While integrated management strategies have been developed for many diseases, they are not always available to resource-poor farmers. Further, successful management of plant diseases is dependent on correct identification of the causal agent, which is knowledge-driven and highly specific. As farmers in developing regions seek to enter export markets, additional pressures are placed upon them to meet quality standards and phytosanitary requirements. Both pre- and post-harvest diseases can pre-empt these attempts to market produce internationally. In addition, importing countries are concerned about the introduction of new pathogens that may greatly harm domestic agriculture. The recent accidental introduction of the select agent *Ralstonia solanacearum* race 3 biovar 2 into U.S. greenhouses on geranium stock originating in Kenya is one example. In many developing regions, plant disease diagnostic capacity is poorly developed to nonexistent; building capacity for plant disease diagnostics in these regions will not only directly benefit farmers but will also help to reduce the risk of accidental introduction of new pathogens into the U.S. In order to address both local needs for timely and accurate plant disease diagnosis and international phytosanitary requirements, capacity for plant pathogen diagnostics in developing regions must be significantly improved. Currently neither infrastructure nor human capital is adequate to meet the needs.

Networking

Establishment of IPDN Regional Diagnostic Laboratories

Good progress was made toward completion of this activity, which is an ongoing effort, in two of the three regions (Central America and West Africa). Small upgrades in equipment and initial reference materials were provided and supplies were purchased by hub labs in these regions. Hub lab operations have been initiated in West Africa and Central America, with increased diagnostic capacity. The third region (East Africa) has been delayed in initiating the project and project adjustments are being made. For the fundraising objective, a proposal was submitted to the Pakistan-US grant program (Pakistan Government/USAID funding) to expand the network into Pakistan/South Asia (funding decisions will be made in November 2006). P.I. Miller has also been in contact with USDA APHIS for funding support of the Year 2 training program and with the Rockefeller Foundation. Linkages have been established between IPM CRSP regional programs in East and West Africa and Central America, and with the Insect-Transmitted Viruses Global Theme.

IPDN communications network

Units for the Polycom system have been purchased and set up in most of the U.S. Universities and host country institutions. Problems with band width in some regions (Africa) have delayed implementation of the program. However, Operations Committees and the full IPDN group have been communicating by email and by Skype, the free internet communication system that also allows inexpensive phone calls and both internet and combined internet/land line conference calls. Listserves have been established for individual Operation Committees and for the group as a whole.

IPDN website

The IPDN website was developed at The Ohio State University and is now available at http://www.IntPDN.org. This website contains details of the stakeholder meetings and training workshops in Central America and West Africa, links to related sites, publications and images. A "Member Communication" list is being developed that will be closed to the general public and password protected. The website is meant to be a networking tool in all of the IPDN regions. The website will continue to be populated throughout this project.

Workshops

Stakeholder training programs in three regions

A plant disease diagnostics training workshop was held in Antigua, Guatemala, June 29, 2006, hosted by site coordinator Agroexpertos. Participants (about 20) were plant pathologists from Guatemala, El Salvador, Honduras, Nicaragua, DOminican Republic and Jamaica. The workshop covered plant disease diagnostics topics including bacteriology, molecular and serological virus detection, nematology, and bacterial wilt diagnosis and management. Presenters were IPDN members from Agroexpertos, Ohio State University, University of Florida and Virginia Tech. The Workshop agenda, photos and Powerpoint presentations are posted on the IPDN website: http://www.IntPDN.org. A second training workshop was held September 7-8 in Cotonou, Benin, hosted by site coordinator IITA. This workshop was attended by 40 West Africans, including representatives from government (SPS, NARs), USAID, FAO, CABI (UK) and universities. The format was similar to that of the Central America meeting, although extended to 2 days of training. Topics included bacterial, fungal and viral diagnostics, and sessions on digital distance diagnosis and the Global Plant Clinic (by CABI). Presenters carried out 6 mini-workshops each over the 2-day period, with 8-10 participants each. Presenters included IPDN members from IITA, Ohio State University, University of Florida and University of California-Davis. The Workshop agenda, photos and Powerpoint presentations are posted on the IPDN website: http://www.IntPDN.org. The workshop for East Africa will be held in East Africa in early 2007.

Diagnostic lab in Africa.

Regional needs for plant disease diagnostics and opportunities for cooperation

A stakeholder meeting and diagnostics training workshop was held in Antigua, Guatemala, June 28-July 3, hosted by site coordinator Agroexpertos. The stakeholder meeting was attended by approx. 30 participants including plant pathologists from six countries and representatives of grower organizations, government (Sanitary-Phyosanitary, SPS), and USAID Guatemala Mission. The IPDN and IPM CRSP were introduced, and the purpose of the IPDN was described. Participants were also given the opportunity to describe their capabilities and needs in diagnostics. A baseline survey (in Spanish or English) of capacity and needs was completed, results of which were published in a poster presented at the Annual Meeting of the American Phytopathological Society in Quebec City in July 2006. A one day training workshop was carried out after the stakeholder meeting, covering plant disease diagnostics topics including bacteriology, molecular and serological virus detection, nematology, and bacterial wilt diagnosis and management.

A second stakeholder meeting and training workshop was held September 5-8 in Cotonou, Benin, hosted by site coordinator IITA. This meeting was attended by 40 West Africans and also included representatives from government (SPS, NARs), USAID, FAO, CABI (UK) and universities. The format was similar to that of the Central America meeting, although extended to 2 days of stakeholder interactions and 2 days of training. The baseline survey (in French) indicated a lower level of diagnostic lab capacity in West Africa than in Central America, and a great need for training in all areas of diagnostics. The stakeholder meeting in East Africa was delayed and will be conducted in Year 3. Spoke laboratories have not been selected to date. Our group is currently re-evaluating the structure of the networks in each region in order to best utilize available resources and maximize stakeholder involvement in the projects.

Sally Miller demonstrating bacterial wlit identification.

Research Activities

PCR-based diagnostic assay for banana xanthomonas wilt (BXW)

PCR primers based on the Hrp gene and specific to the causal agent of banana xanthomonas wilt have been developed at OSU with the cooperation of the IPM CRSP East Africa regional site, IITA and Makerere University. A large collection of strains from Uganda and Rwanda, as well as strains of other bacteria, were screened at OSU. The strains of Xcm show very little molecular diversity by repPCR, RFLP or rapid analyses. A PCR assay was developed and tested against more than 30 strains of Xcm. The assay is highly specific for Xcm, detecting all Xcm strains and no strains of other *Xanthomonas* pathovars or other bacteria. The PCR assay is currently being tested at Makerere University with plant samples. Two monoclonal antibodies generally specific for *Xanthomonas* spp., developed by Dr. Anne Alvarez (Univ. of Hawaii) and currently under license with Agdia, Inc. (Elkhart, IN USA), have been obtained for evaluation. The specificity of the antibodies will be evaluated during Year 2 and if acceptable will be further tested in East Africa.

Assays for Asian soybean rust

Polyclonal antisera were developed against spore antigens of the soybean rust pathogen *Phakopsora pachyrhizi*. Several polyclona antisera were screened against a broad range of extracts from other microorganisms and two antisera highly specific within the genus *Phakopsora* were selected. An indirect immunofluorescence assay was developed for detection of *P. pachyrhizi* spores from spore traps. This assay may be tested in hub labs if appropriate equipment (fluorescent microscope) is obtained. A multiwell ELISA and field-usable immunoassays are under development.

Diagnostic methods for diseases of African indigenous crops

Bacterial wilt was detected on tomato in Benin during Year 1 using commercial immunoassay kits (Agdia, Inc.) A survey of bacterial wilt in Benin and other West African countries will be conducted through the IPDN hub lab in Benin (IITA). Reagents and supplies for isolations and biovar characterization of *Ralstonia solanacearum* will be purchased in the U.S. and shipped to Benin during Year 2.

Integrated Management of Thrips-Borne Tospoviruses in Vegetable Cropping Systems

Naidu Rayapati, Program Leader, Washington State University

The Collaborative Program

This is a collaborative and multidisciplinary team-based project designed to minimize crop losses due to thrips-borne tospoviruses in smallholder vegetable farming systems in South and Southeast Asia. The current phase of the project is focusing in South Asia, with emphasis on tospovirus diseases impacting vegetable production in India, the second largest producer of vegetables in the world and home to 16 percent of the global human population and over a quarter of the world's poor people. The project is developing strong linkages with other IPM CRSP-funded Global Theme and Regional IPM projects and host country institutions as well as strategic partnerships with international agricultural research organizations. This will enhance a spirit of cooperation and integration of research outputs that accrue from partner institutions working together, which leads to a "snowball effect." The project is placing greater emphasis on public-private partnerships and multi-stakeholder participation to extend the application of new science and technology beyond borders and promote eco-friendly IPM practices that will reduce the impact of virus diseases in vegetable production, prevent unintended negative consequences to biological diversity and, more importantly, maintain a quality environment for sustaining life on this planet, as described in *Beyond Silent Spring*.

IPM Constraints Addressed

In recent years, diseases caused by a group of plant viruses called tospoviruses have become a significant limiting factor in the sustainable production of vegetables in the smallholder farming systems of South and Southeast Asia (S&SEA). Crop failure due to these debilitating viruses is creating significant financial hardships and food insecurity for resource-poor farmers in the region. This is resulting in cascading effects such as the loss of family income, an inability to support children's education, and a lack of resources to repay debts and purchase inputs for the next cropping season. These hardships are initiating a downward spiral of abject poverty from which it is very difficult for resource-poor farmers to escape. Therefore, stability of vegetable production promoted through project outputs will have a direct bearing on women's welfare and their household income. Extra income going to mothers through the sale of quality vegetables in the market has a more positive impact on household nutrition, health, and education of children than extra income going to fathers.

Tospoviruses infect a wide range of plant species and are vectored by different species of thrips. Successful transmission of a tospovirus by adult thrips occurs only when the virus is acquired at the first instar larval stage of the thrips life cycle. This type of interdependency between vector life-stage and productive virus transmission is the most complex among currently known plant viruses and involves multiple infection and dissemination barriers related to the metamorphosis of thrips vectors. Consequently, thrips-mediated transmission of tospoviruses is unique among plant viruses in that the process is closely linked to the developmental stages of the vector thrips species. Since tospoviruses replicate in their vectors, viruliferous adult thrips can spread the virus throughout their life. Because registered insecticides give poor control of thrips and the virus can be transmitted within a few minutes of feeding, efforts to control vector thrips with insecticides have been mostly unsuccessful. Moreover, since thrips are small and difficult to identify, pesticides are often used against the wrong species or at the wrong time with no economic benefit. This is further compounded by the lack of sources of host plant resistance and rapid evolution of virulent and resistance-breaking strains of tospoviruses, making it difficult to develop durable resistance in vegetable crops.

There is no "one-size-fits-all" approach to the management of diseases in vegetable crops caused by different tospoviruses, since these diseases have distinct ecological and epidemiological characteristics. Thus, a comprehensive understanding of each tospovirus pathosystem can bring long-lasting solutions for the management of diseases caused by tospoviruses in the region. The IPM CRSP has recently initiated this research project to provide science-based knowledge for developing sustainable and eco-friendly integrated disease management strategies to reduce crop losses due to tospovirus diseases in the S&SEA region.

Networking

Establishment of a network of institutions in South & Southeast Asian countries

Naidu Rayapati has established contacts with PI Sue Tolin and other members of the Global Project on Insect-transmitted Viruses to explore possible collaborations, as well as collaborations with PI Ed Rajotte and other members of the Regional IPM Project in South Asia, and PIs Mike Hammig and Merle Shepard of the Regional IPM Project in Southeast Asia to explore areas for collaborative research and capacity-building on tospoviruses in the region. He coordinated a visit to India in June-July 2006 to jointly explore additional funding opportunities for the projects in India from different agencies and to identify potential areas for collaborative research and capacity-building on virus diseases of vegetables.

Naidu Rayapati and Dr. Ed Rojatte garnered funding under US-India Agriculture Knowledge Initiative (AKI) for the proposal *Improving the capacity for integrated pest management of insect-borne viral disease in Indian vegetable production*. In partnership with AVRDC-The World Vegetable Center, Naidu Rayapati developed a proposal for additional funding to carry out specific activities of the global project on thrips-borne tospoviruses. AVRDC has submitted the proposal to the Asia-Pacific Seed Association for joint R&D activities. Also he established collaborative linkages with Dr. Shyi-Dong Yeh at National Chung Hsing University in Taiwan to access diagnostic reagents for the detection of tospoviruses in vegetables.

Research Activities

Strategic research on tospoviruses and vector thrips species

Thrips-borne tospoviruses are emerging as a significant limiting factor in the sustainable production of vegetables and other economically important crops in the South and Southeast Asia (S & SEA) region. Of the fifteen tospoviruses characterized globally so far, at least seven occur primarily in different crops in the region. In recent years, several of these tospoviruses and vector thrips have assumed greater economic significance due to various factors including pesticide misuse. As a result, the production of quality vegetables by subsistence farmers has been increasingly affected by diseases caused by tospoviruses. Many of these tospoviruses have a broad host range and can perpetuate throughout the year on a variety of crops and non-crop plants. They exhibit a wide range of differences in symptom expression in different host plants and in different cultivars of a host plant, and under contrasting environmental conditions. The extreme symptom differences among different isolates of a tospovirus, similarities between some tospovirus symptoms and those associated with fungal, bacterial, or other viral pathogens are confounding diagnoses of diseases caused by tospoviruses based on visual symptoms. Consequently, the economic significance of tospoviruses in vegetables has been underestimated and recommended disease control measures have become ineffective. Misdiagnosis of tospovirus disease problems is resulting in unnecessary application of fungicides and pesticides with harmful effects on human health and the environment. In addition, virus diseases, if left unchecked, will spread throughout any suitable ecosystem available to them, regardless of national boundaries, and cause crop losses with social and economic impact. The crop failure due to virus diseases has a ripple effect; not only will subsistence farmers move into abject poverty, but those groups who depend on producers, including agricultural laborers, traders, transporters and processors, will also suffer. Although long-term disease management will come through deployment of cultivars resistant to tospoviruses and/or their vectors, in the short-term, a detailed understanding of the nature and diversity of tospoviruses and enhanced diagnostic capabilities will help to minimize virus spread and reduce the economic impact of diseases caused by tospoviruses in vegetables.

Many different species of thrips (Thysanoptera) have been documented in the S & SEA region. Although the vectoring capacity of these thrips is not known, at least six of them are known vectors of tospoviruses in different parts of the world. The minute size of thrips and their cryptic behavior make them difficult to detect either in the field or in fresh vegetables, fruits and ornamental flowers transported through trade and commerce. It is also documented that a single species of vector thrips can transmit more than one tospovirus, and different species of thrips can vector a tospovirus. Since tospoviruses replicate in vector thrips, the insects not only spread the virus throughout their life but also serve as a virus host. Because registered insecticides give poor control of thrips, and the virus can be transmitted within a few minutes of feeding, efforts to control thrips vectors with insecticides have been mostly unsuccessful. As a result, many species of thrips and tospoviruses have now spread from their original natural habitats and hosts to the favorable new environments of valuable crops. Consequently, tospoviruses are seemingly among the most aggressive emerging plant viruses causing widespread losses to several agricultural and horticultural crops worldwide. It has been estimated that tospoviruses cause yield losses up to $1 billion in a wide range of crops worldwide.

Therefore, a complete understanding of tospovirus pathosystems in a given agro-ecosystem will facilitate the deployment of ecologically-based participatory IPM strategies. This will reduce losses caused by tospoviruses, and will allow stable production of quality vegetables and will improve the nutritional value of vegetables consumed. Moreover, it will improve the overall economic well-being of smallholder farmers, many of whom are women, in the S & SEA region.

Principal vector thrips species in vegetables and their vectoring capacity

Ms. Anitha Chitturi from India completed her M.S. thesis in December 2005 at the University of Georgia in the United States. She studied the behavioral patterns (settling behavior and oviposition) of two thrips species (*Frankliniella occidentalis* and *F. fusca*) using a leaf bioassay on intact tomato and peanut plants in order to understand tospovirus epidemiology. Ms. Chitturi joined the graduate program leading to a Ph.D, and completed one semester of coursework in the spring of 2006.

With the experience she gained on thrips at UGA, Ms. Chitturi initiated her research work in India during the summer of 2006. Along with the host country co-PI and the project team, Ms. Chitturi conducted a survey for common thrips vectors infesting tomato, onion, chile peppers, watermelon and eggplant. Sampling methods for collecting different thrips species in vegetables were optimized. The "beat cup" method gave a good number of thrips samples, and was followed by the "beat pan" method. The "beat cup" method was used to collect foliage-feeding thrips, and the "beat pan" method to collect thrips in flowers.

Characterization and diversity of tospoviruses in vegetables

Reconnaissance studies have been carried out to document the occurrence of tospoviruses on three major vegetable crops (tomato, watermelon and onion) grown during the post-rainy season (December - May) and the rainy season (June-November) in the states of Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu. The results described below provided information that was useful in initiating strategic research for an improved understanding of the distribution and diversity of tospoviruses. The results also helped in the development of strategies to minimize the economic impact of tospoviruses in major vegetable crops in smallholder farming systems

Tomato: Bud necrosis caused by Peanut bud necrosis virus (PBNV) is an emerging viral disease in tomato in India (Fig.1). Diseased plants showed symptoms consisting of chlorotic and/or necrotic rings on young leaves. With time, these chlorotic/necrotic rings coalesce, resulting in the necrosis of leaves. The infected plants also showed necrosis of the growing bud as well as necrotic streaks on petioles, stems and lateral branches. Early infection leads to mortality of the plants. Tomatoes produced from infected plants showed concentric rings on the skin and are smaller in size. These fruits have short shelf-lives with poor nutritional quality, and hence are not marketable

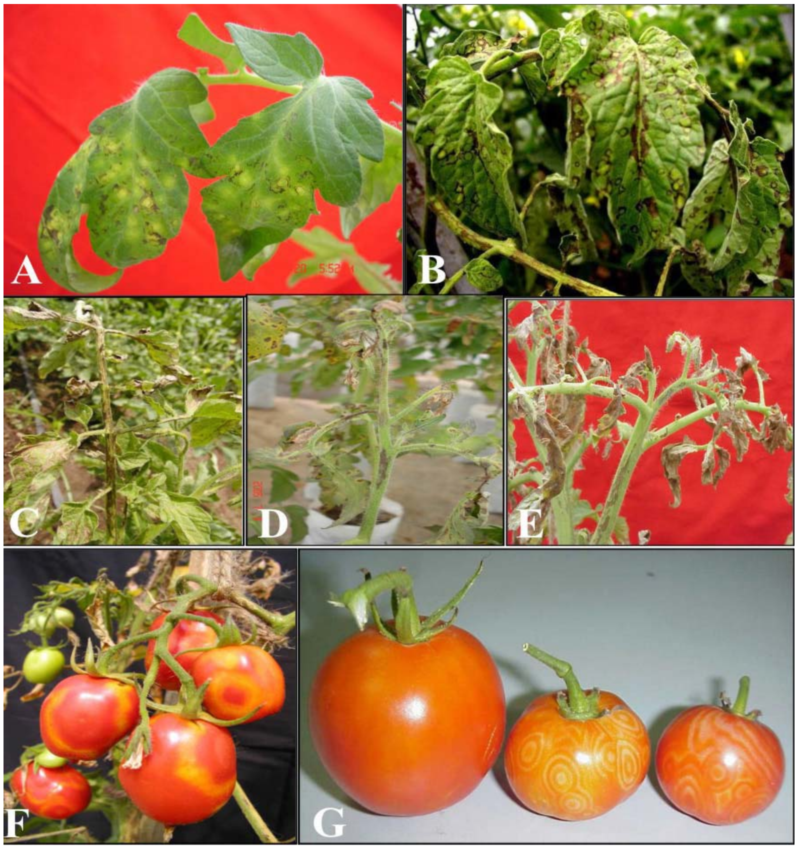

Fig. 6. *Peanut bud necrosis virus* causes necrosis and death of tomato plants. Symptoms include (A) chlorotic spots with necrotic rings on leaves, (B) severe necrosis of leaves, (C, D) petiole and stem necrosis, (E) necrosis of growing buds leading to the death of the plant, and (F, G) concentric chlorotic rings on tomatoes from virus-infected plants. Note reduced size of two tomatoes from virus-infected plants on the right in Fig. 1G.

The major tomato growing regions of Maharashtra, Karnataka and Andhra Pradesh states were surveyed for the occurrence of PBNV. The disease incidence varied from 3-30 percent among the fifteen major tomato growing locations surveyed. Samples from plants showing typical bud necrosis symptoms were collected and tested for different tospoviruses by direct antigen coating-enzyme-linked immunosorbent assay (DAC-ELISA). All samples tested positive for PBNV. In addition, suspected samples from chile pepper, eggplant and okra fields also tested positive for PBNV. The results indicated wide distribution of PBNV in different vegetables.

Total nucleic acids were extracted from ten representative samples among those that tested positive for PBNV. The nucleocapsid (N) gene was amplified, cloned and sequenced. Pairwise comparison of N gene sequences with corresponding sequence of an isolate of PBNV published earlier showed nucleotide sequence identity between 97.9% and 99.0% and amino acid sequence identity between 97.8-100%. These preliminary results indicate that the N gene is highly conserved among PBNV isolates.

Watermelon: *Watermelon bud necrosis virus* (WBNV) is an emerging constraint to the production of watermelons in Southern India. Like PBNV, WBNV also causes necrosis of growing parts of the stems as well as leaf and petiole necrosis, which leads to the death of the plant (Fig. 2). Early infection leads to total loss of the crop. Plants infected at a later stage produce fruits; however, these fruits are small and deformed with chlorotic and/or necrotic rings and blotches on the skin. Such fruits are not preferred by the consumers due to reduced quality. Hence, WBNV has a greater economic impact on the production of watermelons in India. In recent years, farmers are shifting cultivation of watermelons from the summer to the winter season to avoid losses due to WBNV. However, the shifting cultivation is not solving the problem since it leads to off-season production which results in decreased income generation for the farmers.

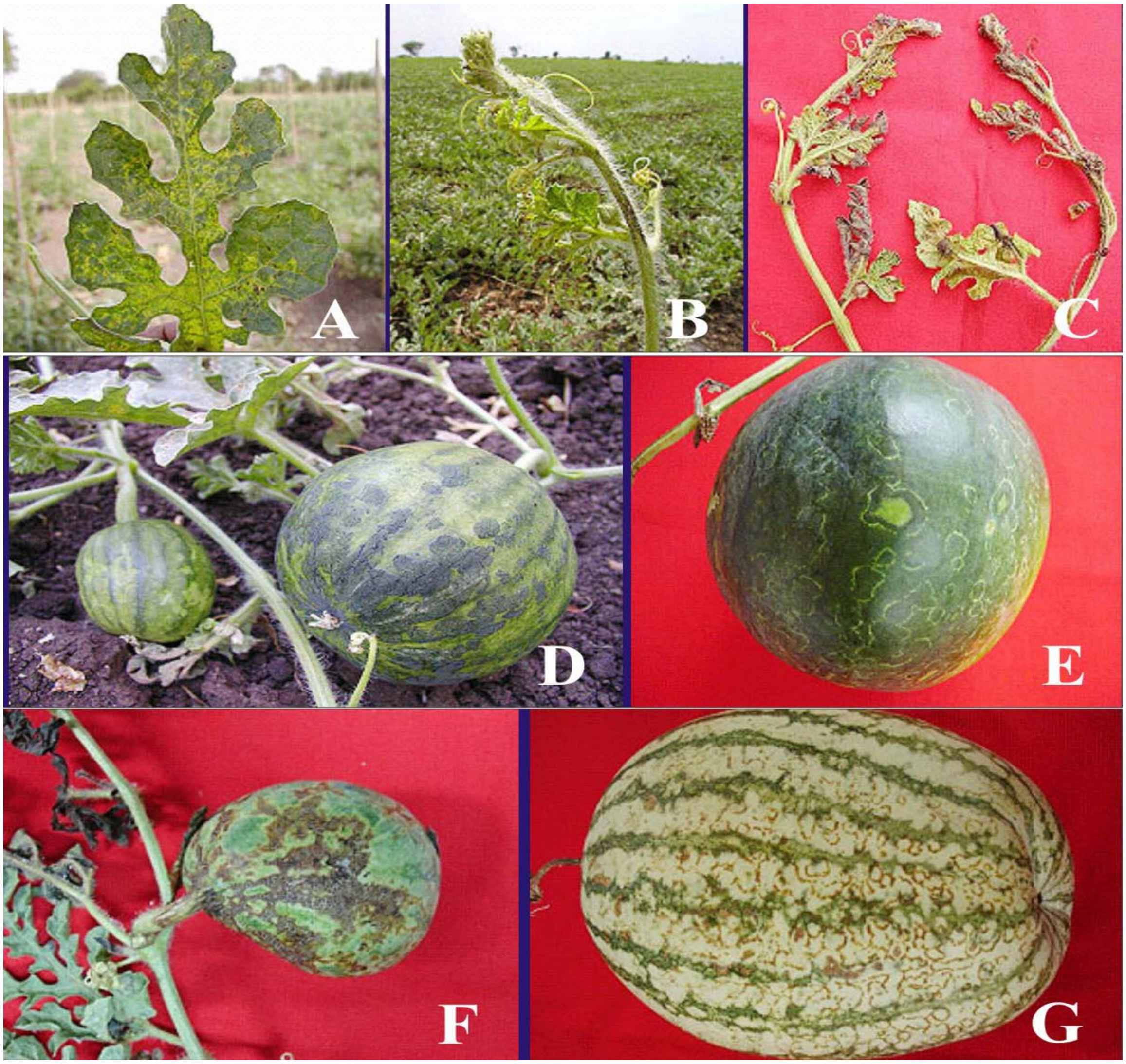

Fig. 2. Watermelon bud necrosis virus causes necrosis and deformities in fruits. Symptoms include (A) chlorotic rings and mosaic mottling on leaves, (B) necrotic streaks on stems, and (C) necrosis of growing buds leading to the death of plants. Fruits from infected plants show a broad range of symptoms ranging from chlorotic blotches (D), chlorotic rings (D), malformations (E), and necrotic rings and blotches (F).

During the year 2006, the watermelon growing regions of Maharashtra (Jalna, Beed, Aurangabad, Parbhani and Solapur), Karnataka (Dharwad) and Goa were surveyed for watermelon bud necrosis disease. The disease incidence varied from 3-80 percent. However, a high incidence of watermelon bud necrosis was observed in Karnataka State as compared to Maharashtra State. Symptomatic samples collected from 46 fields in 16 different locations tested positive for WBNV in DAC-ELISA using polyclonal antibodies against WBNV. Four representative WBNV isolates are being maintained under greenhouse conditions on watermelon by regular mechanical sap inoculations for molecular studies of the virus genome.

Total nucleic acids were extracted from 16 representative WBNV isolates from Maharastra and Karnataka states. The N gene was amplified, cloned and sequenced. Pairwise comparison of these N gene sequences with a corresponding sequence of an isolate of WBNV published earlier showed nucleotide sequence identity of between 91.90% and 99.5% and an amino acid sequence identity between 95.6% and 100%. Phylogenetic analysis of N gene sequences of WBNV isolates is in progress.

Onion: Onion is one of the most economically important crops grown in Maharashtra state. Indeed, Maharashtra is the number one producer of onions in

India. In recent years, the incidence of yellow spot disease caused by *Iris yellow spot virus* (IYSV) has been increasing in many onion growing regions of the state. A survey was undertaken in the Pune, Nasik, Ahmednagar, Parbhani, Jalna, Beed, Aurangabad and Buldana regions of Maharashtra state and the Dhrawad district of Karnataka state to estimate the prevalence of the virus disease in onion. The disease incidence was as high as 50% in some of the onion fields surveyed. The most typical field symptoms of the disease are spindle-shaped lesions on scapes and flower bearing stalks. The symptoms are highly variable and could result in misdiagnosis of infection as a fungal disease. Severe infection leads to a coalescence of spindle-shaped lesions resulting in the withering or drying of plants. Bending of flower stalks and necrotic lesions lead to flower abortion.

Out of 47 IYSV isolates collected from 37 locations from Maharashtra and Karnataka states, 20 isolates tested positive in DAC-ELISA using polyclonal antiserum specific to INSV. The N gene from 16 isolates collected from Maharastra state was cloned and sequenced.Pair-wise comparison of the 16 N gene sequences revealed sequence homology between 95.99% and 99.8% at the nucleotide level and 95.9% and 100% at the amino acid level. Preliminary results from a comparison of the N gene sequences of Indian IYSV isolates with corresponding sequences of IYSV isolates from different countries indicated closer phylogenetic relationships of Indian isolates with Eurasian isolates (Israel, Netherlands, Japan and Australia) than with those reported from the Americas (United States, Brazil, and Chile).

Membrane-based diagnostic methods for the detection of tospoviruses

The initial approach was to test the available antibodies to different tospoviruses for their utility in diagnosing tospoviruses in vegetables. For this purpose, polyclonal and monoclonal antibodies against several tospoviruses from different sources were obtained. They include: polyclonal antibodies against *Tomato spotted wilt virus* (TSWV, DSMZ, Germany), *Watermelon silver mottle virus* (WSMoV, DSMZ, Germany), *Impatiens necrotic spot virus* (INSV, DSMZ, Germany), *Peanut bud necrosis virus* (PBNV, Mahyco Research Center and ICRISAT, India), *Peanut yellow spot virus* (PYSV, ICRISAT, India), *Iris yellow spot virus* (IYSV, DSMZ, Germany), *Chrysanthemum stem necrosis virus* (CSNV, DSMZ, Germany), *Tomato yellow fruit ring virus* (TYFRV, DSMZ, Germany) and *Peanut chlorotic fanleaf virus* (PCFV, Taiwan). In addition, 13 monoclonal antibodies raised against nucleocapsid (N) and non-structural (NSs) proteins of seven different tospoviruses: PBNV-N, (Taiwan and India), TSWV-N (DSMZ, Germany), INSV (DSMZ, Germany), WBNV-N (Taiwan), CaCV-N (Taiwan), WSMoV-N (Taiwan) and WSMoV-NSs (Taiwan) were obtained. These antibodies were used for testing a broad range of vegetables (tomato, chili, eggplant, legumes, watermelon, and onion) for the presence of different tospoviruses. The summary of the results are:

- Optimized direct antigen coating (DAC)- and triple antibody sandwich (TAS)- formats of Enzyme-linked immunosorbent assays (ELISA) for the detection of PBNV in vegetables, WBNV in watermelons and IYSV in onions.
- In DAC-ELISA, polyclonal antibodies raised against PBNV detected both PBNV and WBNV isolates from different host plants.
- In DAC- and TAS-ELISA, monoclonal antibodies raised against WSMoV-N, WSMoV-NSs and PBNV-N proteins detected PBNV and WBNV isolates. However, monoclonal antibodies raised against WBNV-N and CaCV-N proteins failed to detect PBNV isolates. Preliminary results have shown that WBNV-N specific monoclonal antibodies could detect WBNV isolates only.
- In DAC-ELISA, polyclonal antibodies raised against IYSV-N detected IYSV isolates only.

The antibodies for the detection and discrimination of three different tospoviruses (PBNV, WBNV, and IYSV) prevalent in vegetables in South Asia have been identified. These antibodies offer better tools to delineate symptoms caused by tospovirus infections than those caused by fungal diseases.

Collaborative Assessment and Management of Insect-Transmitted Viruses

Sue Tolin, Virginia Tech

The Collaborative Program

The program is led by US-based researchers at Virginia Tech, University of Arizona, University of Georgia, and University of California at Davis. The project collaborates with scientists in tropical countries and islands of the Western hemisphere (Guatemala, Honduras, Dominican Republic, Jamaica) and in arid lands of East Africa (Mali, Burkino Faso, Cameroon), and also brings in AVRDC-The World Vegetable Center and their locations in West Africa and Central America, and with IITA in Tanzania. There is also interaction with IPM CRSP Global Themes on Diagnostics, Impact Assessment, and Information Technology, with a parallel project on thrips-transmitted viruses in India and Thailand, and with several Regional IPM Centers. This program enables scientists to rapidly diagnose plant diseases caused by viruses, identify vectors of the viruses, and advise farmers on ways to reduce losses to their crops by reducing and delaying infection. With knowledge of virus and vectors, approaches to managing diseases through intelligent decision-making can be designed by affecting the biological and physical environment, and through development of resistance, together with timely and strategic use of insecticides aimed at controlling vectors. The objectives of developing a crop-specific database of viral diseases, appropriate diagnostic methods, ecologically based management practices, and resistance are applicable world-wide.

IPM Constraints Addressed

Viruses are prevalent in cultivated crops worldwide, particularly in developing countries. The most problematic viruses in vegetables are DNA viruses in the family Geminiviridae transmitted by whiteflies (begomoviruses), and RNA viruses in the families Potyviridae and Cucumoviridae transmitted by aphids. Design of IPM systems for viral diseases requires proper virus identification, knowledge of virus ecology and diversity, and a rapid means of virus detection and monitoring. If all components of the virus/vector/crop ecosystem can be identified, integrated disease management can be devised to interfere with virus spread by vectors. Alternatively, genetically resistant crops can be developed through collaborative research of virologists, molecular geneticists, and plant breeders.

Research Activities

Inventory of insect-transmitted and other viruses of vegetable crops in Central America and the Caribbean

A format for the Virus Information database was agreed to, and data were collected and entered for viruses known to infect tomato in North America, Central America and the Caribbean. Data fields include host and virus species, genus, and family; genome type, size, and sequence(s) in Genebank by accession number; coat protein size(s); serological test availability for each virus; transmission characteristics including seed, mechanical, and vector; geographic distribution, and symptoms. A comprehensive review was undertaken this year by FHIA’s Department of Plant Protection. Around 550 laboratory records were examined of analyses performed for detection of viral diseases on samples of Cucurbit and Solanaceous crops during the last 5 years. A form for recording information of the samples collected was shared with collaborators for its suitability with the information specialists of the project. It includes details of all samples they have received that have suspected or confirmed viral diseases. Analyses are in progress.

Assessment of diagnostic capabilities in Central America and the Caribbean

Diagnostic facilities and scientists at FHIA and Zamorano in Honduras, and at University del Valle in Guatemala were found to be excellent, with capabilities for ELISA and PCR. A new laboratory was under construction at CERA in Dominican Republic that is expected to be operational within a few months. Jamaica has PCR and DNA sequencing capabilities at the UWI, and ELISA both at UWI and the MOAL. Both groups are routinely conducting tissue blot immunoassays for TEV. The status in the African countries will be determined at the October meeting. Zamorano in Honduras, through Millenium Challenge Funding and a subcontract with FINTRAC, was able to purchase ELISA kits and immunostrips from Agdia in the US and from Central Scientific Laboratories in the United Kingdom, and to send samples for evaluation and testing.

The Project Director and collaborators from Guatemala, Honduras and Jamaica participated in the IPM CRSP Diagnostics global theme meeting in Antigua, Guatemala. The PD presented talks on virus diagnosis and demonstrated the use of Agdia immunostrips by detecting TMV on tomato. A survey taken among the stakeholders attending the meeting revealed that diagnosis of viruses was the most difficult group of pathogens for most laboratories in the region. Our collaborators in the three countries above are the primary ones in each of these countries capable of viral diagnosis.

Diagnostic capabilities in Central America

In Honduras, a new project awarded to FINTRAC by the Millenium Challenge Fund provided funding for the purchase and use of diagnostic kits to identify a much larger number of samples than was could be done by the IPM CRSP. The results of these studies were disseminated to technical-extension personnel.

Sixty tomato, weed and pepper (*Capsicum anuum*) samples were tested at Zamorano by AGDIA immunostrips to 4 common viruses (TMV, CMV, TSWV, INSV) and 20 samples were sent to AGDIA for a virus screen (total of 30 viruses). In tomato, the only viruses testing positive were TMV (100%) using Agdia Immunostrips and Begomoviruses (78%) using a generic PCR assay. Most pepper samples were negative for most common viruses including potyviruses PVY and TEV, or Begomovirus, but a few were positive to CMV. No potyviruses, TSWV or INSV found in any of the samples. No phytoplasmas were found in more than 500 tomato or pepper samples tested by PCR between 2004-2006. Additional samples have been collected in September and sent to Agdia for a complete virus screen to confirm these results. Tomato and pepper samples were sent to Brown´s laboratory from Zamorano to test for crinivirus and TYLCV. Selected samples were also sent to CSL for further testing of criniviruses and viroids. The virus in eggplant and ornamental peanut was preliminarily diagnosed by Roca at CSL lab in England by conventional ELISA and by Immunostrips (Pocket Diagnostics). This is believed to be the first report of TYLCV in eggplant.

Distribution and genetic characterization tobacco etch virus infecting peppers in Jamaica

In Jamaica, the major virus in Scotch Bonnet and other hot peppers (*Capsicum chinense* var. Jacq.) is TEV. A research project involved molecular analysis of TEV collected from four locations. The nucleotide sequence was determined for three regions of the TEV genome, namely the coat protein (CP), the helper component proteinase (HC-Pro), and the P1 proteinase regions. Phylogenetic analyses concluded inferred all TEV isolates were indistinguishable and formed a single clade, suggesting a single introduction of TEV into Jamaica. At the amino acid level, CP was 66.8% to 100% similar, indicating certain variable regions, with specific amino acid substitutions correlated with location of isolate. Sequences in the HCPro region were 88.9% to 99.6% similar with typical highly conserved domains. Too few P1 regions were sequenced to permit analyses. Additional work is needed to examine more isolates from throughout Jamaica, and other regions of the TEV genome.

IPM strategy for viruses in the Salama Valley of Guatemala

Surveys were conducted in selected pepper and tomato plantations in Salama indicated that the prevalent insect-transmitted virus problem was a mixture of begomoviruses, including *Tomato severe leaf curl virus*, *Pepper golden mosaic virus*, and a *Pepper huasteco yellow vein virus*-like begomovirus. However, due to the wide range of symptoms detected, it is likely that these viruses are occurring in mixtures and more than these four begomoviruses are involved. In addition to begomoviruses, symptoms of mottle/mosaic were observed and these were attributed to *Tobacco mosaic virus* (TMV). There is a disease caused called chocolate spot, caused by an unidentified virus-like agent. Squash blot-PCR detection method failed to find evidence of phytoplasma infections in these samples. Thus, based on these initial findings, an IPM program based upon the following steps has been proposed: 1) a mandatory host (pepper/tomato)-free period, 2) evaluation of new cultivars (e.g., with TMV and begomovirus resistance), 3) selective use of insecticides (e.g., neonicotinoids and/or insect growth regulators), 4) biological control of whiteflies, 5) use of row covers to keep whiteflies and other insect pests off plants at a young age, and 6) extensive sanitation. After extensive discussions with growers and others involved with tomato production in Salama, it was agreed that the best time for the host-free period might be sometime from May-July.


Sue Tolin with IPM collaborators.

IPM strategy for the Ocoa Valley in Dominican Republic

At the Ocoa Valley all plants in a tomato field were showing symptoms of TYLCV in spite of seedlings having been produced under cover. A second field was showing symptoms other than TYLCV, but diagnosis has not yet been made. TEV, TMV, and CMV are suspected. Viral diseases are the main constraints in vegetable crops on green peppers and tomatoes. In this region in 2000 a pepper yield of 230,979 qq. was reported, whereas a yield of 76,522 qq. was obtained in 2001. That reduction on the yield is believed to associated be with diseases caused by viruses transmitted by insects such as tobacco etch virus (TEV), cucumber mosaic virus (CMV) and tomato yellow leaf curl virus on tomatoes (TYLCV).

In April 2005, a survey was conducted at Sabana Larga, El Pinal and Nizao in order to assess the incidence of TEV on peppers, but TYLCV on tomato was also included. The incidence was observed in farmer fields based on visual symptoms in four pepper fields and 7 tomato fields. Symptoms characteristics of TEV in pepper and TYLCV in tomato were observed in every field from planting day until fruiting time. The percentage incidence varied from 8% at the beginning (15 days after transplanting) to 90% at the end of the period when observations were stopped.

Monitoring the temporal epidemiology of TYLCV in whiteflies to assess success of a host-free period

The three-month period when no hosts for the virus or for whiteflies can be grown in an area has been a key component of a successful IPM program for the management of this damaging virus. Whiteflies were collected in the north and south where the strategy was used, and from two locations in the Ocoa Valley where there is no host free period. In October 2005, after the end of the host-free period, TYLCV was not detected in the whiteflies collected in the North or the South; in contrast, TYLCV was detected from whiteflies collected from Ocoa. Whiteflies from the North and South remained TYLCV-free through December. By the end of January, when the tomato-growing season was well underway, virus was in 20% of samples from the South and 50% from the North and from Ocoa. Incidence fluctuated through the end of the growing season in late May 2006. At the end of June, during the host-free period, only 10% of whiteflies from the North and 30% from the South were TYLCV-positive. Whiteflies sampled in July, August and September from the north were all negative for TYLCV, whereas those from the south were 10%, 20%, and 0%, demonstrating that the host-free approach is continuing to be successful in reducing the incidence of the virus before the planting of tomatoes.

Spatial and temporal dynamics of TYLCV in tomato in Jamaica

An experiment was conducted on the Agricultural Experimental Station at Bodles, St. Catherine, Jamaica, W.I., from 6 February through 26 April 2006. Tomato seedlings grown in screenhouse to exclude whiteflies prior to transplanting, and tissue blots were taken from random plants at transplanting to confirm absence of TYLCV. Field spread of TYLCV followed the logistic model, beginning at 3 initial loci of infection in Week 2, and increased from 20% cumulative incidence at Week 4 to 80% in Week 7.

Monitoring whitefly populations in Jamaica

Whitefly populations were monitored in two southern parishes of Jamaica, St. Elizabeth and St. Catherine, where tomatoes are grown. Population dynamics of whitefly varied between parishes and between districts in each parish. In each district whitefly activity varied significantly with time ($p < 0.001$). Analyses of factors affecting the population fluctuations may suggest planting time choices or other practices to reduce whitefly vectors early in a tomato cropping season, and reduce incidence of TYLCV.

IPM packages for aphid-transmitted viruses in pepper

An experiment was conducted by S. McDonald on the Agricultural Experimental Station at Bodles, St. Catherine, Jamaica, W.I., from 22 June to 30 August 2006 to monitor cumulative incidence of TEV on pepper in split plots either 3m or 24m from an old pepper field, and with or without a corn barrier.

Under the high inoculum potential conditions, all plants were infected by the 10 weeks after transplanting. Distance of the plot from the inoculum source tended to reduce the time and rate of spread, as measured by cumulative incidence of infected plants in the plot. Neem plus straw mulch tended to result in a slower infection rate that did either treatment alone.

Development of an agroinoculation system for TYLCV from the Dominican Republic

Because of the increasing importance of TYLCV in the Dominican Republic and the spread of the virus throughout northern Mexico and, more recently, into southern Texas, there is an urgent need to develop and identify TYLCV-resistant varieties. Gilbertson (UC-D) has generated a full-length clone of TYLCV from a squash blot sample from Ocoa using PCR and overlapping primers. The infectivity of the clone was confirmed in *Nicotiana benthamiana* plants by particle bombardment inoculation. The clone was then inserted into the binary vector pCAMBIA1300 and the recombinant plasmid transformed into *Agrobacterium tumefaciens*. Agroinoculation of this clone into tomato results in typical TYLC symptoms in 10-14 days. This system is now being evaluated at UC-Davis for routine screening of tomato germplasm for TYLCV resistance.

Use of transgenic resistance to viruses

Information on regulations in collaborating countries for testing and growing transgenic plants was obtained, and deployment of virus resistant plants discussed. Honduras and Jamaica have policies in place to obtain permits for field testing of plants engineered to be virus resistant. No regulations are in place for approval of crops for commercial purposes. In the last IPM CRSP, initial transformants of tomato were made that contain sequences from TMV or *Tomato mosaic virus*. With the widespread incidence of this virus complex in Honduras and Guatemala, such plants could be used in strategies for disease management. However, discussions concluded that a commercial seed company would have to be recruited to advance the transformed lines.

Use of induced resistance for virus disease management

In Jamaica, induction of resistance in hot pepper to TEV by bacterization (biocontrol) was demonstrated as a part of the M. Phil. thesis at UWI. A *Bacillus* spp. suppressed virus accumulation as measured by ELISA over time, and a *Pseudomonas* promoted plant growth and suppressed symptom development. The mechanism is suggested to be by induction of systemic acquired resistance.

Viral diseases and vectors in African cropping systems

Samples were collected in Cameroon cropping systems involving cassava, okra, two types of eggplant, and sweetpotato. In Burkina Faso, the cropping system involves tomato, potato, onion, beans, cucurbits, cassava, and cabbage, with over 250 improved varieties of food and horticultural crops, vegetables, legumes, and cereals. Studies of vectors in these cropping systems will be linked with the West Africa Regional IPM Center activities.

Identification and deployment of vegetable varieties with resistance to prevalent viruses

AVRDC identified the following lines of pepper, okra, bottle gourd and cucumber with potential geminivirus resistance, and increased them in AVRDC fields in winter 2005/spring 2006:

- *Capsicum* sp. (365 lines and accessions)
- *Lagenaria siceraria* (bottle gourd) (30 lines)
- C*ucumis sativus* (cucumber) (25 lines)
- *Abelmoschus esculentum* (okra) (21 lines)

Seed of the above were sent to Mali and Honduras. These seeds will be planted in 2006/2007 for screening in the field by disease incidence and symptoms. In Burkina Faso, 40 AVRDC varieties were tested by the tomato biotechnology program, and observed by collaborator Koutou. Only 10 were moderately productive (10.2 tons/ha), and were 100% infected with TYLCV-Mali and *Pepper yellow vein Mali virus*.

Applications of Information Technology and Databases in IPM in Developing Countries and Development of a Global IPM Technology Database

Yulu Xia, North Carolina State University

The Collaborative Program

This global theme program mainly collaborates with 1) other regional and global theme programs through IT and database consulting; 2) West African Regional IPM CRSP program on network information about whiteflies; and 3) Southeast Asia IPM CRSP program that concentrates on networking information on pests. It also collaborates with USDA APHIS on pest information sharing in Africa, the Caribbean, and Asia. It works with Bionet on training in use of database for sharing information of invasive species.

IPM Constraints Addressed

This global theme addresses the issues such as information sharing, delivering, and data analysis in the areas of IPM research, education, and practices. It does not directly deal with the issues such as pest management, pesticide use, and biodiversity. It is basically a type of information service.

Communication and Networking

Development of decision support tools

Decision support tools can play significant role in pest management. The typical tools in the category include decision support systems (DSS), expert systems, and databases. The databases/information systems and other decision support tools developed from or provided by this project will enhance capacity in research, training, education, extension, and IPM practice, help communication of pest information among the regions and host countries, expand reach of IPM data and information. It also improves the quality of policy making by providing sound information and efficient communication channels. Three databases and three web sites were developed.One workshop was conducted.

Whitefly information system: This program has worked with the regional program to identify the major services and information that this system could provide. An online interface (framework) has been developed. Users utilize the site to view the potential service and data. It is anticipated that a large amount of data and graphics will be entered into the system next year.

Yula Xia examining crops in Indonesia.

Interactions models, visualization and communication

GIS, databases, and web application projects for visualization and improved understanding and communication of biotic and economic interactions will be developed through collaboration with regional and global theme programs, and host country institutions. It helps in communication among scientists, IPM practitioners, growers, and policy makers in reference to pest population dynamics, interactions of biological and non-biological factors in agricultural pests and their natural enemies. It will help understanding the factors that impact pest population and control outcome. Penn State and RADA (Rural Agricultural Development Authority, Jamaica) worked together to get all stakeholders involved in this program. The evaluation of status of current hardware and software in the region has been completed.

Agricultural pest information storage and pest monitoring

Crop pests in three regional programs have been identified and they are being included in the system. Substantial programming work has been completed. Web interfaces and database were designed and they are functional. Three dedicated web sites were established. Preliminary data and links were reported. Databases are partially populated.

A substantial amount of data and links will be completed in the coming years. One in Southeast Asia and a second one in West Africa were conducted.

IT support and capacity building

All the IPM CRSP programs involve IT and database applications and this global theme program provides necessary technical support and consultations. Hardware and software were purchased and installed West Africa, Southeast Asia, and the Caribbean.

Metadata defined, web and dynamic programming partially completed and extensive programming works have been conducted. Training workshops were conducted in West Africa and Southeast Asia in association with the regional planning meetings.

Link to USDA Regional IPM Centers' information and IPM CRSP reporting system

The linked system will provide users such as IPM CRSP researchers and host country scientists with a single access site for searching relevant IPM information. It will enhance efficiency of IPM research and extension.

Sites and systems have been identified by working with the collaborators in regional and global theme programs. Three regional IPM websites have been developed. Users are submitting links and data to the site. All major links will be completed by next year.

IPM Impact Assessment for the IPM CRSP

George Norton, Virginia Tech

The Collaborative Program

The global theme on IPM impact assessment is a collaborative program lead by researchers at Virginia Tech, IFPRI, and the University of Minnesota to guide and coordinate economic and gender impact assessment programs of the regional and other global theme programs on the CRSP. The Virginia Tech component also includes a faculty member who is a gender specialist at the University of Denver. The IPM impact assessment program works with the site chairs and coordinators to standardize the approaches used for impact assessment and to help with analyses in some cases. The program is developing consistent and integrated, spatially-referenced datasets to support IPM impact assessments at multiple scales and to facilitate the projection of which IPM interventions are likely to have the greatest impacts locally, nationally, regionally, and globally. It coordinates with other IPM programs at IARCs and with other USAID-supported agriculture and natural resource management programs on developing and applying assessment methods that provide the most relevant and strategic information in consistent and appropriate formats for specific target audiences.

IPM Constraints Addressed

This global theme program addresses the need for consistent and rigorous application of IPM impact assessment methods. It provides data and analyses that can be used for strategic analysis of IPM priorities nationally, regionally, and globally.

Development of a common set of methods

A common set of methods will be organized around a matrix that establishes the linkages among, data, methods, and impacts at various geographic scales and on different types of outcomes. Field data will be combined with other information (e.g., adoption rates, prices) and with models for producing indicators of impacts on income, poverty reduction, nutritional improvement, or health/environmental improvement.

Identification of minimum data needs, models, and impact indicators at each level.

Minimum data needs for impact assessment have been established for each program and sample forms for collecting information for impact assessment have been shared with the regional site programs, including forms for data collection for constructing budgets for experiments and sample baseline surveys. A list of steps for impact assessment has been circulated. Data collection for impact assessment, including baseline surveys, was begun in most regional programs by the programs themselves.

Collaboration with scientists in each IPM CRSP regional and global theme site to apply assessment methods to evaluate impacts of specific IPM CRSP activities.

Collaborating with scientists (including social scientists) in the regional programs, the common components of the methodology to be applied in each region as noted above are: a) baseline surveys (where funds permit in the regional programs); b) collection and budgeting of experimental and price data in standardized formats; c) assessment of farmer adoption of IPM technologies; d) GIS and economic surplus analysis of market-level impacts of IPM; e) calculation of poverty impacts; and f) data collected on changes in pesticide use for farmers who adopt IPM technologies, estimation of changes in environmental and human health risks and their perceived value. Other indicators and benchmarks for human capacity building and contributions to IPM-related science will be calculated as well.

Baseline surveys: In two sites, South Asia and West Africa, G. Norton was involved both in suggesting and in implementing baseline surveys. A graduate student from India, who is in the Agricultural Economics masters program at Virginia Tech, Atanu Rakshit, worked with BARI in Bangladesh to implement the baseline survey there. In Mali, a baseline survey was implemented by IER (led by Madame Gambi and Samba Soumare) with the help of economists from IITA (Ousmane Coulibaly and Theo Nouhohelin). For his MS thesis, Mr Rakshit is focusing on the economic and environmental impacts of Pheromone traps in Bangladesh in addition to assessing factors influencing adoption of IPM in Bangladesh. He is funded partly on this project and partly on the South Asia regional site program. A second MS student, Melanie Victoria, is beginning her research on assessing gender impacts of IPM CRSP work in Asia. She too is partly funded on both the impact assessment and the South Asia programs.

Graduate student gathering information for the baseline survey.

Development of consistent and integrated, spatially-referenced and tabular datasets

Development of a consistent, integrated, spatially-referenced and tabular datasets for IPM impact assessments for 15-20 commodities locally, nationally, regionally, and globally will be led by Minnesota and IFPRI (and also using funds from other sources) in order to address a larger set of commodities than would be possible with IPM CRSP resources alone. This activity will support IPM impact assessments at multiple scales and facilitate the projection of which IPM interventions are likely to have the greatest impacts locally, nationally, regionally, and globally.

Collection of production, consumption, price, and crop performance data to simulate pest control benefits: Phil Pardey (Minnesota) and Stan Wood (IFPRI) have collected geo-spatially recorded data on crop production, prices, trade, and potential versus actual yields on 20 commodities to use in an analysis of strategic priorities of pest problems globally. A PhD student (at Minnesota), Jason Beddow, is working with us to gather information on crop-pest losses at a disaggregated level for this large set of major crops.

Collaboration with other IPM programs at IARCs and with other USAID-supported agriculture and natural resource management programs on developing and applying assessment methods

Collaboration occurred with researchers at the following CGIAR centers: IITA, CIP, IFPRI, ICARDA, and IRRI. In addition, there was participation in a CG sponsored workshop on impact assessment at the 26th meeting of the International Association of Agricultural Economists in Australia. Also in the Australia conference, Virginia Tech and IFPRI participated in a symposium session organized by USAID on impact assessment as part of the USAID Impact Assessment Task Force activities.

Facilitation of access to the methods, tools, applications and analyses

Extension and Dissemination of information on IPM impact assessment methods beyond the IPM CRSP will occur through publication of articles, an impact progress report series, a book, and through the Worldwide Web, (both through the IPM CRSP website and through the IFPRI website). The methods will be spread though presentations at professional meetings both within the disciplines and at meetings such as the National IPM Symposium in St Louis in 2006. Presentations will be made at workshops affiliated with USAID, USDA regional IPM Centers, and with the IARCs when impact assessment methods are discussed. We will organize a workshop at IFPRI during the last year of the project with both internal (to the project) and external participants.

Assessment methods and analyses to a broad audience: A mini symposium was organized at the 6th National IPM Symposium at St Louis in April 2006 with an attendance of roughly 100 participants. There were four presentations in the two hour mini-symposium, two by IPM CRSP impact assessment researchers. In addition two other presentations were made on impact assessment at other sessions in the National symposium. Methods were also discussed in several other presentations.

Training of graduate students and other scientists

Three MS students and two PhD students were partially funded on the IPM impact assessment program. Atanu Rakshit (at VT) from India helped with the baseline survey in Bangladesh and with other impact assessment there and Melanie Victoria (at VT) from the Philippines is working on gender impact assessment methods. Jason Beddow (at Minnesota) is working on compiling the datasets for strategic IPM impact assessment. Jessica Bayer (VT) is assessing the regulatory costs associated with *BT* biotechnology. Vida Alpuerto (at VT) from the Philippines has just begun her program on IPM Impact Assessment.

TECHNOLOGY TRANSFER PROGRAMS

Technology Transfer Activities in Mali

Larry Vaughan, Virginia Tech
Kadiatou Toure Gamby, Site Research Coordinator, Institut d'Economie Rurale
Bourema Dembele, Site Administrative Coordinator, Institut d'Economie Rurale

Managing Tomato Viruses among Small Scale Producers

Over the past 10-15 years in Mali and other countries in West Africa, epidemics of viral disease, associated with high populations of whiteflies, have plagued tomato production, severely reducing yields and, in some cases, making the cultivation of tomato no longer economically viable. Indeed, the extent of this problem in Mali is best illustrated by the fact that the country has gone from being a net exporter to a net importer of tomatoes.

In order to gain a better understanding of the nature of this problem and to develop strategies to increase tomato production in Mali, IPM-CRSP has been involved in a project aimed at: 1) identifying the nature of the viruses involved, 2) identifying improved tomato varieties that are resistant or tolerant to the viruses and are horticulturally acceptable for West African farmers and consumers, and 3) developing and initiating an overall program for tomato production that includes integrated management of the tomato virus diseases. Together with IER personnel, surveys of tomato-producing areas in Mali have been conducted. Using DNA probes and polymerase chain reaction (PCR), it was established that most of samples of tomato leaves were infected with a whitefly-transmitted begomovirus(es). More extensive examination of these samples via PCR amplification, cloning and DNA sequencing of the viral genome revealed that three distinct whitefly-transmitted geminiviruses are involved. These were named after the host plant they were first detected in, the predominant disease symptom type, and the country (Mali): *Tomato leaf curl Mali virus* (TLCMV), *Tomato yellow leaf curl Mali virus* (TYLCMV) and *Pepper yellow vein Mali virus* (PYVMV). The cloned DNA of these viruses and their genetic sequences were then used to develop additional biotechnology tools, specific to these viruses, for studying their distribution and biology (e.g., types of plants infected). The results of these studies revealed the following: 1) TLCMV and PYVMV were the most prevalent geminiviruses in tomato, 2) the viruses were detected primarily in tomato and pepper but not in weeds and other crops, and 3) a PCR test was developed that would allow detection of all of these viruses in whiteflies.

The village of Baguineda was selected as a test area for the transfer of this technology in the form of an integrated pest management (IPM) strategy to combat these viruses. The keys to the program are: 1) an area-wide two month host-free imposed (i.e. no tomato or pepper allowed) in and around Baguineda with the help of local extension personnel; 2) extensive sanitation efforts to remove and destroy tomato and pepper plants after harvest; 3) screening and evaluation of new improved varieties; and 4) monthly monitoring of whitefly populations and virus incidence to understand the impact of these practices on the target problem.

The host-free period was July and August 2006, and a vigorous education program was initiated to inform farmers why this was needed. Surveys conducted during this period revealed little tomato or pepper production and that whitefly populations had dropped precipitously. Farmers were provided the seeds of the improved varieties for planting in September 2005 and 2006; immediately after the end of the host-free period. In 2005, the plantings were not done as soon after the host-free period as hoped. Many farmers waited until October-November 2005 to plant. Together with the rapid increase in whiteflies and virus in whiteflies during September-October, viral disease increased faster than expected. Even under these conditions, the early maturing hybrid varieties yielded much more than the traditional open pollinated varieties, Roma and UC 82.

An interesting finding of the area-wide survey was the documentation that levels of whiteflies peaked in November-December and then declined noticeably on tomato crops by the end of December. This resulted in lower whitefly and virus pressure on tomato crops planted from the end of December through early January. Indeed, yields obtained during this growing season (January-May) in 2006 with the early-maturing varieties have been very good. In fact, the tomato production generated with these varieties in 2006 was reportedly the highest in 15 years. Furthermore, the fruit of these varieties was deemed acceptable for local markets and, due to their longer shelf life, fruits of these varieties had higher quality and commanded a better price. The local farmers in Baguineda have now attributed this revival in tomato production to the host-free period and the use of the new varieties.

Application of 2006 Host Free-Period in Baguineda, Mali

Since 2004, a two-month host-free period has been tested during July and August in the irrigated perimeter around village of Baguineda, an area comprising 22 villages. The control area for Baguineda is Kati, 55 km from Baguineda and separated from it by the Niger River and hills. In collaboration with the Extension Office of Baguineda, meetings were held in April to May in villages. Villagers learned the importance of the destruction of tomato and pepper plants for the July/August host-free period and the need to plant tomatoes quickly the first part of September as soon as the host-free period is over.

Although a total elimination of tomatoes and peppers during July and August 2006 was not obtained, the situation was much better than for 2004 and 2005. From 2003 to 2006 the area of “illegal” tomato and pepper plants dropped from 13.56 ha to 0.0475 ha.

Screening of Tomato Germplasm for Resistance or Tolerance to Leaf Curl Virus

From 2004 to 2006 tolerant /resistant tomato varieties to TYLCV disease were screened at the station and in farmers’ fields in Kati and in Baguineda. These tomato varieties were released during the first growing season (September-December) and the second growing season (January-May). Cultivars for testing in farmer’s fields were those selected by farmers during their visits to station trials.

Station: In 2004, with no bacterial wilt in the trial, yields in new varieties varied from 15 t/ha for Gempride D1 to 30 t/ha for Heinz H6703, whereas susceptible varieties in the control group (Roma VF and UC-82) produced no more than 7t/ha. The station trials suffered bacterial wilt during 2005 and 2006. In either the absence or presence of bacterial wilt, new cultivars yielded more than farmers’ commonly used cultivars Roma VF and UC-82.

Farmers’ fields: Tolerant/resistant cultivars were released into farmers’ fields during the first and second growing seasons. As in the situation with the on-station trials, resistant/tolerant varieties performed better than the commonly used susceptible varieties such as Roma VF and UC-82.

The varieties H8804 and Shasta appear to be the most interesting. Shasta, in addition to its tolerance were prized by farmers because of the fact there was low fruit loss due to contact to the soil. These varieties have been released again into farmers’ fields. A new IPM CRSP activity will be designing a plan for making the best varieties commercially available.

Best Researcher Award

Kadiatuau Toure Gamby, head of the fruit and vegetable Research Program and national coordinator of the IPM CRSP Mali site received the 2006 Best Researcher Award from the Institut d’Economie Rurale in Mali.

Technology Transfer in Uganda

Mark Erbaugh, The Ohio State University

Assessment of IPM Farmer Field Schools in Eastern Uganda.

A survey of 165 farmers to assess the impacts of farmer field schools (FFS) on adoption of cowpea and groundnut IPM technologies has been conducted and data coded and entered for analysis. Respondents' surveyed indicated that 112 (68%) had participated and 53 (32%) had not participated in FFS; and 63% were female and 37% male. Preliminary analyses also indicate that participants compared to non-participants were significantly more knowledgeable of IPM and dimensions of IPM such as identification of natural enemies; awareness of alternatives to pesticides for controlling pests; and awareness of possible negative consequences from using pesticides.

Makerere University sponsored farmers field school.

IPM Packages for Control of Pests of Tomatoes in Central Uganda

Through four farmer field schools, 180 farmers have been introduced to the IPM tomato package. The IPM package for tomato includes a resistant variety (MT56) + mulching + 3 sprays/season + staking, and has resulted in reduced incidence of Bacterial wilt, aphids, thrips and white flies. Pesticide applications have also been reduced from the farmer control of 8 to 3 sprays per season. The yields were 40% higher from IPM plots. Farmer open-days were also hosted at the four locations.

Farmers field school in Uganda.

Thirty five farmers belonging to three farmer groups were trained in grafting using two indigenous solanaceaous root stocks as a method to control bacterial wilt (*Ralstonia solanacearum*). 86% of all graftings done by farmers were successful. However, only *S. complycatnum* root stocks were completely resistant to bacterial wilt and *S. indicum* root stocks were susceptible to BW. Farmers were able and interested in learning grafting technique and are even using it on other crops like passion fruit. A manual on grafting has been produced in the local language for use by farmers.

Pests and Diseases of Hot Peppers

On-farm trials were conducted with four farmers to determine the incidence of insects and diseases on hot pepper and the losses. There were 3 treatments: Control (No spraying at all), Spraying every two weeks (farmers' practice) and spraying every 3 weeks. Yield loss was assessed by picking at random, 200 fruits per treatment and categorizing them into marketable and unmarketable fruits. The pests observed were aphids, Cercospora leaf spot and a complex of viral diseases. Fruit fly damage was the most important contributor to unmarketable fruits.

Pesticide Applicator Safety

The Pesticide Application and Safety Training Course has now become institutionalized and is conducted twice yearly in July/August and February/March. It is now a requirement of the Uganda Agricultural Chemicals Board that a certificate of course attendance be obtained before applicators can be registered. Participants were recruited through a combination of approaches. The first is advertising the course in newspapers, with those interested registering and paying a nominal registration fee. The second approach is through NGOs interested in promoting safe pesticide use; specifically the Uganda National Agro-input Dealers Association (UNADA) and the Appropriate Technology Uganda LTD (AT-U) collaborated in selecting and sponsoring participants. The final approach is where the IPM Scientists select farmers involved in pepper and tomato production to attend the course. In this reporting year, two sessions were conducted one for training of trainers (TOT), carried out in October 2005, and the other one for pesticide applicators and farmers conducted in February 2006.

There were 31 participants at the TOT training session of which 2 were females and 29 males.
Each of the 31 Trainers, has trained over 100 farmers each under the IPM CRSP and AT Uganda supervision and support. Consequently a total of 3000 farmers have been trained through this arrangement. The trainers are using a manual developed through collaborations with the IPM CRSP titled: Manual for Pesticide Dealers and Applicators on Safe Handling and Application of Pesticides. Also, over 500 copies of Safe Pesticide Use Brochure have been distributed.

Banana Bacterial Wilt (BBW) *Xanthomonas campestris* pv. ***musacearum*** strain identification
More than 120 isolates from Uganda and Rwanda have been assembled by Makerere University and IITA Uganda. These have been shipped to The Ohio State University (S. Miller lab) for use in development of diagnostic assays.These isolates from diverse areas in Uganda were screened using restriction fragment length polymorphism (RFLP) analysis of a section of the *Hrp* gene and random amplified polymorphic DNA (RAPD) analysis of total genomic DNA. Based on RFLP analysis with enzymes *Rsa* 1 and *Hae* III and RAPD analysis, no diversity was observed in the population of Xcm in Uganda. Further analysis of more than 40 Xcm strains from several East African countries by repPCR also demonstrated a very low level of variation among strains.

Technology Transfer in Central America – Guatemala and Honduras

Steve Weller, Purdue University

Technology Transfer of Fruit Bagging in Guava and Star Fruit

Fruit bagging technology to control fruit-fly (*Ceratitis capitata* and *Anastrepha* spp.) in Guatemala guava and star fruit was transferred to growers and technicians in conjunction with Instituto Técnico de Capacitación –INTECAP (Technical Institute of Qualification and Productivity) and the Technical Mission of Taiwan. This technology was directly transferred to 150 people and then these trained people taught an additional 1500 people. The method of information transfer was "to learn from practice". Demonstrations of fruit bagging technology that results in fruits free of med fly was done in ten production fields in Guatemala. Model plots demonstrated the recommended practices for each crop and then ten producers were trained and used the method on their farms. The technology was by farmers in several production areas of Guatemala and included: Cuyuta, Escuintla, Petén, Retalhuleu, Santa Lucia, and Tiquisate. Fifteen of the one hundred fifty participants directly taught were women, while 10% of the other 1500 taught were women. Growers employing fruit bagging technology can expect to reduce use of insecticides by about 50%.

IPM manual for Mediterranean fruit fly management

A manual for management practices that help control med-fly in guava and star fruit was completed and is titled: "Protect Your Guava *Psidium guajaba* L. from Flies *Ceratitis capitata* Whiedmann and *Anastrepha* spp. Schner. (Diptera:Tephritidae)". The manual is available electronically on the ICTA's (Institute of Agriculture Science and Technology) website (http://www.icta.gob.gt) and 1000 hard copies were printed for distribution to stakeholders. The manual is being distributed by ICTA, ICADA (Central American Institute for Agricultural Development), agriculture universities and agriculture companies working with growers in Guatemala.

Research Activities

Melon production in southern Honduras

Melon, one of the most economically important export-oriented crops in Honduras, is experiencing a recurring "vine collapse" issue that began in the late 1990's and can result in 50% yield loss. This research is designed to identify causes and management practices that reduce or prevent its occurrence. 2006 research focused on biological control of soilborne diseases, and the feasibility and effect of mycorrhizae inoculation to plants in absence of fertilizer.

Biological control trials included mycorrhizal fungus *Glomus intraradix* (BuRize®), the antagonistic fungus *Trichoderma lignorum* (Mycobac®) and *Bacillus subtilis* (Serenade®). Only *Bacillus subtilis* inoculation resulted in enhanced vine length, but at harvest no differences in yield and disease occurred with any treatment. The mycorrhizae inoculation without fertilizer trial examined the impact of a high fertilizer regime on colonization of roots by the fungus. Results suggested that melon is not a good candidate crop for use of mycorrhizae because it is a short season crop.

Linking IPM research to public school curricula in Guatemala

IPM CRSP collaborators completed a *Didactic Guide* for dissemination of IPM principles to public school curriculum experts and teachers in Guatemala. The guide includes a teacher's manual and student learning materials that allow transfer of IPM knowledge and perspectives to teachers, students, and parents in Guatemala's NUFED secondary schools. The didactic IPM materials focus on snow pea production in a context that includes the biology of the plant, the ecology of snow pea production, and market-based SPS requirements. Didactic materials were developed by a team that included a biochemist, an educational psychologist/teacher, and social scientists familiar with snow pea IPM, along with an advising agronomist/IPM specialist, who incorporated IPM CRSP snow pea research findings into the guide.

Technology Transfer in the Caribbean

Sue Tolin, Virginia Tech

Threshold-Based Management of Pests Affecting Leafy Vegetables with High Pesticide Input

Regionalization of methods to rationalize pesticide use on leafy vegetables

Methods to rationalize pesticide use in leafy vegetables which began in year I were advanced in year two with the establishment of demonstration plots on cabbage farms in other major vegetable growing regions in Trinidad (Cuara Valley)and Jamaica (Mavis Bank).

Cabbage (Tropicana variety) was transplanted in small test plots using standard agricultural practices for soil preparation, fertility, weed management, irrigation, and plant spacing of 18"x 18" that are relevant to a particular island (Jamaica or Trinidad); and these practices were constant for all test plots on the island. For demonstration plots in Trinidad, treatments included a grower standard (Match®) and a microbial insecticide (Tracer ®/Spinoace®), each applied on either a weekly schedule or according to a threshold, and an untreated control. Crop yields were compared among the treatments. For Jamaica, due to the inability to obtain the insecticide Spinoace®, exclusion using row covers was compared with calendar-based weekly sprays (farmer practice) and an untreated control.

The threshold-based system of monitoring and timing of pesticide applications for major pests (Lepidoptera) on cabbage, which was being demonstrated in the plots, were highlighted during the training as well as the potential of thresholds to reduce pesticide input in cabbage production without compromising marketable yields.

Field days were conducted at each of the sites. In Trinidad, approximately 40 farmers and 30 other stakeholders attended the field day. In Jamaica there were 23 participants comprising farmers from three cabbage-growing districts, extension officers and representatives from Jamaica 4-H Clubs and Peace Corps (attached to the area). Participants in the training sessions expressed that the experience was a valuable one and were particularly impressed with the obvious efficacy of the IPM methods despite reduced (by 37.5%) to no pesticide inputs compared to farmer practice.

This work was executed in collaboration with the Ministries of Agriculture and Rural Agricultural Development Authority (RADA) in Jamaica. In Trinidad, this activity inputs the new approaches directly into the curricula of successful farmer field schools established in that country, providing a basis for sustainability through continued farmer-to-farmer training.

Reinstating Callaloo to the USDA APHIS Preclearance List in Jamaica

The United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) has initiated the process to replace the vegetable amaranth (callaloo) on to the preclearance list. This action is in response to a dramatic reduction of pest interceptions in shipments of fresh callaloo submitted for export to the USA, from an average of 38% in 1997 to 2.5% in 2005, according to interception records. The annual average number of shipments of fresh callaloo to the USA is 150. The collaborative on-farm research demonstration and training conducted under the IPM CRSP was credited with this notable improvement in product quality. Consequently, USDA APHIS invited CARDI/IPM CRSP to play a key role in training exercises as part of the initiative to reinstate the commodity on the preclearance list. Specific areas of focus in the training sessions included Preclearance requirements, Standards, Callaloo IPM, and Post harvest handling. It should be noted that a callaloo wash basket designed under the CARDI/IPM CRSP for increased efficiency of disinfesting callaloo stalks, was displayed and demonstrated at these sessions.

During 2006, four training sessions were held in Linstead, St Catherine (for Eastern Jamaica) and Catherine Hall, St James (for Western Jamaica). Participants included not only exporting farmers but also extension and quarantine officers who will be involved in farmer certification exercises in the east and central sections of the island, and exporters. These training activities were supported in mainly by funds allocated for technology transfer.

Sue Tolin with IPM CRSP trainee.

Sweetpotato Production System Practices

Impact assessment

After a series of discussions with root crop researchers locally and regionally, the plan of work for sweetpotato was amended from conducting training workshops to assessing the impact sweetpotato IPM training sessions conducted over the past seven years for both farmers and extension officers in the major sweetpotato producing islands of the Caribbean (St Kitts and Nevis, Montserrat, St Vincent and the Grenadines, and Jamaica). Specifically, the assessment was designed to (i) assess the changes in the knowledge, skills and attitudes of extensionists and farmers that have been trained, (ii) determine the impact of trainings on the extension programme of local agencies, and (iii) establish how these changes have impacted productivity, markets, product development and income of farm families and communities.

Baseline data have been collected and a series of survey tools developed that seek to address the objectives stated above. These survey instruments are currently being refined to meet the needs of the various islands. Additional data that will be used to develop a sampling plan are also currently being collected from each of the islands included in the study. It should be noted that assistance was sought from the Principal Investigator of the Impact Assessment Global Themes project (Dr George Norton) to ensure that the approach is in congruence with the work being conducted within this project.

After the instruments are completed (Dec 2006), they will be field tested before the wide scale survey is conducted (Jan-Feb 2006). The data collected will then be analysed and the findings used to refine training curricula and plan future research activities.

Information products

At a meeting held with root crop researchers in St Vincent (May 2006), areas in which farmers were having difficulties were identified. Training guides are being developed to addresses these shortcoming. Training guides include:

- Diagnosis of sweet potato soil pests
- *Phyllophaga* sp. (biology and ecology)
- General agronomy of sweetpotato
- Physical characterization of local export sweetpotato varieties

GIS Implementation and Training in the Caribbean

Shelby Fleischer, Pennsylvania State University

To date, a GIS pest surveillance and mapping facility has been developed. This facility includes web-based data entry, automated database maintenance, automated data mapping and generation of time-series graphics, and automated hypertext linkage of all graphics into an operational webpage. Training in GIS, GPS, and web-deployment of these integrated informational technologies for pest surveillance has been conducted, and we are currently building the human infrastructure to will bring this on-line across multiple island nations. The organizations we are working with include CARDI, University of the West Indies, and PROCICARIBE through CIPMNet. Work to date includes personnel from the Ministries of Agriculture from Dominica, St. Lucia, Jamaica, Antigua, St. Vincent, Trinidad and Tobago, and Grenada. We will build GIS linkages for facilitating establishment and implementation of biological controls through CABI scientists at their Trinidad offices. We will expand into the Spanish and French speaking nations through our Caribbean-wide organizations listed above, and using our software facilities that are already designed to be rapidly adopted for multilingual applications. In addition, GIS/GPS/web-deployment training sessions will be held annually to introduce novices to the power of this technology and enhance existing skills, and we will begin to introduce additional spatial thematic layers relevant to IPM. We will work with USDA APHIS and the island nations, to help protect both US agriculture and the island nations from pest invasions.

Technology Transfer in Southeast Asia

Michael Hammig, Clemson University

The Collaborative Program

Indonesia and the Philippines are the selected host countries for this project. Both countries have large agricultural sectors that provide the bulk of food needs for their large and growing populations, and they are ecological "hot spots" for losses of biodiversity. Vegetables and other high-value crops are typically produced by communities of intensive small farm operations located in ecologically sensitive areas. Families depend on farm revenue as their major – often exclusive – income source. Therefore, production risk issues are of paramount importance, and pest management ranks as the most important source of production risk.

The project includes seven research activities across nine research sites. In the Philippines, research will focus on IPM for tomato and eggplant in Batangas, Nueva Ecija, and Nueva Viscaya Provinces; strawberries in Benguet Province; and rice/vegetable systems on Mindanao. In Indonesia, research on vegetable IPM will be centered in North Sumatra, North Sulawesi, and West Java. Cocoa IPM will be studied in North and South Sulawesi, and the rice/vegetable system work will be replicated in Lampung Province. It also includes activities to ensure that the research is participatory, involving farmers, extension workers, NGOs, IARCs, and national research agencies, as well as scientists from U.S. universities and USDA.

IPM Constraints Addressed

Specific pest problems differ from location to location throughout the Southeast Asia region; in general, however, these problems are the result of excessive indiscriminate use of synthetic chemical pesticides to control agricultural pests. Both Indonesia and the Philippines have undertaken successful efforts to provide IPM training to farmers, but these efforts have largely focused on rice. Vegetables and other crops have much more complex pest problems than rice, and synthetic pesticide use by vegetable farmers is much more intense than for rice.

Development of IPM systems for vegetables and other high-value crops presents challenges to researchers, but the payoffs are substantial. The objectives of the project will be attained by focusing research and training efforts in selected important growing areas in Indonesia and the Philippines. In the Philippines, in collaboration with the University of the Philippines at Los Baños (UPLB), PhilRice, IRRI, Local Government Units, and AVRDC, sites are located at Batangas, South Luzon; Benguet, Nueva Viscaya, and Nueva Ecija ,Central Luzon; and Arakan Valley, Mindanao. In Indonesia, primary collaborators, in addition to the Indonesian Ministry of Agriculture Agency for Agricultural Research and Development, are *Insitut Pertanian Bogor* (IPB) [Bogor Agricultural University] in West Java, Sam Ratulangi University (Unsrat) in North Sulawesi, Hasanuddin University (Unhas) in South Sulawesi, and the Regional Development Planning Board, FIELD Indonesia, and Development Alternatives Inc. (DAI) in North Sumatra. The major vegetable and selected other high value crops in each region are the focus of IPM development through research, field demonstrations, direct farmer training, institutional capacity building, and establishment of a regional communications network for the exchange of ideas and accomplishments.

Farmer Field Schools

From May to October 2006, four FFS groups were established in two villages: FFS on tomato (Lau Debuk-debuk Farmer Group) and FFS on leek (Lau Tumekap Farmer Group) in Doulu village, and FFS on tomato (Sibayak Simalem Farmer Group) and FFS on leek (Kertah Ernala Farmer Group) in Semangat gunung village. In each FFS the farmers compared local practice of using chemical fertilizers and synthetic pesticides with ecological treatment of applying chicken manure, compost and botanical pesticides.

Technology Transfer in the Philippines

Sally Miller, Ohio State University

High-Impact IPM Strategies

The Southeast Asia site in the Philippines developed several high-impact IPM strategies for onion and eggplant during the first IPM CRSP. The approach was primarily research-oriented, but technology transfer is now underway. Influenced by the efforts of the IPM CRSP, PhilRice, the lead institution for this site, has adopted a crop systems approach to research and outreach for rice production that includes vegetables and other high value crops. Activities were focused on the technology transfer of the following IPM CRSP developed technologies for rice-based crops particularly onion and eggplant.

Insect pest management – for onion:

- No spraying for the first 20 days after planting
- Use of pheromone traps as a tool for timing of intervention for cutworm (*Spodoptera litura*) and armyworm (*S. exigua*).
- Use of nuclear polyhedrosis virus (NPV) for cutworms
- Use of yellow board sticky traps for leafminer (*Liriomyza trifolli*)
- Use of blue sticky board traps for onion thrips

Insect pest management for eggplant (and other vegetables)

- Use of pheromone traps as a tool for timing intervention for eggplant shoot and fruit borer (*Leucinodes orbonalis,* cutworm (*Spodoptera litura*), armyworm (*S. exigua*) and the tomato fruit (*Heliothis armigera*)
- Weekly removal and proper disposal of damaged fruits and shoots to manage the eggplant fruit and shoot borer.

Disease management – onion and other vegetables

- Use of vesicular arbuscular mycorrhizae (VAM) in the seedbed against soil-borne pathogens and as a soil amendment
- Use of Trichoderma sp. (T5 ipm crsp isolate) in the seedbed against soil-borne pathogens
- Use of Trichoderma sp. (T5 ipm crsp isolate) as a seedling root dip or soil drench at the time of planting/transplanting against soil-borne pathogens
- Grafting of eggplant in places where bacterial wilt is a problem
- Proper timing of fungicide applications for foliar diseases (if needed only)

Weed management

- Stale seedbed technique mechanical
- Stale seedbed technique chemical

Training

Direct training

Short-term trainings for farmers, agricultural technologists and other stakeholders were conducted. The activities started with discussions with the local government units (LGUs) of several municipalities regarding the possibility of holding an intensive training/workshop on IPM in rice-vegetable cropping systems. Selection of sites was based on the need and interests of the community, and willingness to share in the expenses for the training and other logistics. The Department of Agriculture (DA)-LGUs selected the participants and determined the number of participants. We have completed 13 training programs in 13 municipalities. A total of 1031 farmers and technicians were trained. Of the 1031 participants, 786 (76. 2%) were males and 245 (23.8%) were females.

Training of trainers

Thirty-eight extension workers and farmer leaders attended the Training of Trainers on Integrated Pest Management on Vegetables in Rice-based Cropping Systems held on July 31 to August 4, 2006 at PhilRice CES. The 5-day training was developed to improve awareness, access, understanding, and use of pest management technologies for rice-vegetable cropping system in Nueva Ecija, Nueva Vizcaya, Pangasinan, Bataan and Ilocos provinces. Course content included the cultural management practices in onion production; insect pest and diseases of onion and their management; weeds and their management; insect pests and diseases of eggplant and other vegetables and their management; use and production of VAM, *Trichoderma* sp. (T5 ipm crsp isolate), sex pheromone traps and sticky board traps; tips on the production of training materials; facilitating skills; proper handling of pesticides; motivators; social mobilization; and action planning. Training methods used were participatory lectures, discussion, workshop, and hands-on exercises. The majority of the participants came from Nueva Ecija (37%)

followed by Ilocos Sur (24%), Pangasinan (13%) and Ilocos Norte (13%), Nueva Vizcaya (8%), and Bataan (5%). Fifty-five percent were male and 45 % female.

Training on the use and mass production of VAM and Trichoderma sp.

Hands-on training on the mass production of VAM and *Trichoderma* sp. (T5 ipm crsp isolate) was conducted. These are the two technologies with high demand for disease management in onion and other vegetables. Farmers believed that these two technologies can really reduce their pesticide inputs and will have better assurance of producing good yield with less expense, thus higher net income. Farmers formed themselves into several groups, supervised by the agricultural technologists of the municipality or barangay, and we demonstrated the procedures. Farmers brought their own materials like sterilized soils and pots for VAM production. For *Trichoderma* sp. (T5 ipm crsp isolate) production, they provided their own corn grits, plastic bags, rubber bands, kettles and steamers, firewood for cooking and improvised cooking stoves. Several groups had their own *Trichoderma* sp. (T5 ipm crsp isolate) for use. A total of 814 participants from 147 villages were trained in the mass production of VAM and *Trichoderma* sp. (T5 ipm crsp isolate). Of the 814 participants, 625 (76.8%) were males and 189 (23.2%) were females. Farmers who used VAM and *Trichoderma* sp. (T5 ipm crsp isolate) reported very good yield.

Trichoderma production in the Philippines.

In Northern Philippines, the use of VAM and *Trichoderma* sp (T5 ipm crsp isolate) is becoming very popular. Several groups of farmers have tried mass producing and using them. Farmers claim that they are very effective and can save on fungicide costs. Hence, more and more farmer groups are mass producing them for their own use. Some groups are looking at the possibility of producing them for commercial purposes. A group in Nueva Vizcaya (Aritao Organic Farmers Association) has even procured a grinding machine for the *Trichoderma*. They are planning to commercialize the product soon although this has to be registered with FPA first. For insect pests, the use of the sex pheromone traps for cutworms, armyworms and the eggplant shoot and fruit borer, and the yellow sticky board traps for onion leafminer were very much accepted. IPM CRSP provides pheromones in the meantime while waiting for the commercial availability of the pheromones. Farmers are willing to buy the pheromones if made available because they are convinced that their use of insecticides will be greatly reduced, thus less input costs, higher income and healthier food and environment.

Knowledge and campaign materials

The field guide on major insect pests and diseases of onion in Onion-Rice Cropping Systems has been produced. The book on IPM in Rice-Vegetable Cropping Systems is in press. Other campaign materials are three videos with estimated running time of 3-5 minutes each.

Most of the IPM technologies disseminated to farmers in the Philippines have been focused on rice production. Outside the IPM CRSP, technology transfer and training activities on vegetable IPM in rice-based cropping system have been very limited. The IPM technologies developed by IPM CRSP in the Philippines for onion and other vegetables are now being transferred on a wider scale in the country. The use of sex pheromone traps to time applications of insecticides is now being practiced by several farmers. Similarly, the application of VAM and *Trichoderma* sp. (T5 ipm crsp isolate) for the management of soil-borne pathogens had been proven by farmers to be beneficial, thus, several farmers are now mass producing them for their own use. This indicates that the technologies being promoted are socially acceptable, economically beneficial with high probability of sustainability.

The training/workshop activities conducted during the period had been found to be an excellent means of transferring or disseminating these technologies to the farmers. Broadcast news releases, newspaper articles and websites also helped in the dissemination. Farmers' associations and cooperatives are now preparing for the mass production of VAM and *Trichoderma* (T5 ipm crsp isolate) for commercial purposes. There is no doubt that these technologies can be applied in other countries. The IPM CRSP in the Philippines will continue to work with more farmers throughout the country.

Institution Building

Technology transfer activities of IPM CRSP are jointly funded by PhilRice as part of its current mission to include vegetable IPM as a component of its rice-based farming systems program.

Networking

Networking is accomplished through institutional collaboration between PhilRice, the University of the Philippines Los Baños (UPLB), Central Luzon State University (CLSU) and the Local Government Units (LGU) of the IPM CRSP sites. The PhilRice-JICA TCP3 in Northern Philippines is also collaborating in the training and technology transfer activities on vegetable IPM in their sites.

Women packaging *Trichoderma.*

Technology Transfer – Bangladesh

Ed Rajotte, Penn State University

Technology transfer activities were carried out by BARI scientists in a number of locations in Jessore, Narsingdi and Gazipur districts. Mennonite Central Committee (MCC)-Bangladesh (NGO) collaborating with IPM CRSP-BARI transferred IPM packages for healthy and profitable productions of eggplant, tomato, cabbage and cucurbit crops in Comilla and Sirajganj districts.

Two more international NGOs, ActionAid-Bangladesh and Practical Action-Bangladesh teamed up with IPM CRSP-BARI in June 2006 to take part in the transfer of IPM technologies, developed by IPM CRSP-BARI for vegetable crops, through the European Commission (EC)-funded FoSHoL (Food Security for Sustainable Household Livelihoods) program. CARE- Bangladesh, which teamed up in 2003, also joined the other NGOs to disseminate IPM CRSP-BARI technologies through the FoSHoL program. IPM CRSP organized a 3-day "Training of Trainers" (ToT) program for the field officers of the above three NGOs. They received theoretical as well as practical training on the IPM CRSP-BARI technologies; BARI scientists associated with IPM CRSP acted as the trainers.

The research programs were conducted at BARI farm in Gazipur. The pest management research encompassed (a) Biological control of eggplant and cabbage pests; (b) Test of Bt protein Cry1Ab strain against eggplant fruit and shoot borer and (c) Varietal evaluation for resistance to pests in eggplant, tomato and pumpkin. BARI scientists visited the demonstrations and experiments at regular basis.

IPM Constraints Addressed

The key constraints addressed in Bangladesh were the need for IPM solutions to specific pest problems in vegetables and the need for information on socioeconomic factors influencing adoption of IPM. The specific major pests being addressed in the IPM programs included eggplant fruit and shoot borer (*Leucinodes orbonalis*), bacterial wilt (*Pseudomonus solanacearum*) in eggplant and tomato, fruit fly in cucurbit crops, diamond-back moth and other leaf-eating insects in cabbage, root-knot nematode in eggplant and tomato, virus diseases in sweet gourd (pumpkin), and pod borer and virus disease in country bean.

Highlights of Technology Transfer Activities

The technologies of IPM packages disseminated and demonstrated at different sites were: (a) for higher and profitable production of eggplant; (b) for higher and profitable production of tomato; (c) for higher and profitable production of cucurbit crops; and (d) for higher and profitable production of cabbage.

Achievements

IPM package for higher and profitable production of eggplant

IPM package for eggplant production were carried out at two locations (Chaigharia village of Salikha Upazilla and at Khanpur village of Bagharpara Upazilla) of Jessore site, one location of Narsingdi, and one location at Jamuna village in Gazipur.

Jessore site. One farmer raised 3,000 seedlings of grafted on a wild eggplant rootstock, *Solanum sissymbrifolium* for bacterial wilt (BW) resistance and sold them to three farmers for cultivation in about 0.33 ha. The mortality of the grafted plants averaged only 6.7% (range 5.6% to 7.7%) compared to much higher mortalities in non-grafted fields. As a result crop establishment was highly satisfactory producing higher yields and higher economic returns (BCR= 2.98 to 3.98; Average=3.3).

Jamuna village of Gazipur district. Cultivation of grafted eggplant was demonstrated in a small farmer field with 300 grafted seedlings along with soil amendment with decomposed poultry refuse and three hand weeding. Only 4.5% grafted plants died compared to 28% of the non-grafted plants due to bacterial wilt disease. The grafted plants had luxuriant growth and produced 197% higher yields (53Kg/plant) compared to 27Kg/plant in the non-grafted field. The grafted plants produced 144% higher yield. The grafted plants had (52fruits/plant) and (42gms/fruit) compared to 36fruits/plant and 28gms/fruit in non-grafted ones.

Belabo village of Narsingdi district. About 700 grafted seedlings were planted in a small farmer field. Removal of FSB infested twigs and two hand weeding were also practiced. The demonstration trial had a mixed success because of wrong cultural practices adopted by the farmers. There were high plant mortalities due to bacterial wilt disease (BW) in the non-grafted field (78%) as well as in the grafted field (52%). In spite of high plant mortalities, the grafted field produced 196% higher yield (14.7t/ha) compared to 7.5t/ha in the non-grafted field. The grafted plants produced 192% higher Yield. The grafted field produced 12.5 fruits/plant and 32.4gms/fruit versus 6.5 fruits/plant and 18.7gms/fruit in non-grafted field. The demonstrations created positive impact on the farmers because of the effects of the grafting technology in controlling BW disease and higher yield and economic returns.

Grating eggplant and tomatoes in Bangladesh.

IPM package for higher and profitable production of tomato

In Bangladesh, tomato is cultivated mainly in the winter season when BW disease is not as severe as in the summer season. A small scale demonstration of grafted summer tomato was therefore demonstrated in farmer fields at Boteswar village in Narsingdi district and at Jamuna village of Gazipur district. Two summer tomato varieties, BARI Summer Tomato-3 and BARI Summer Tomato-4 were used as scions for grafting on a wild eggplant rootstock, *Solanum sissymbrifolium*. Grafting success averaged 94%. At both the locations, the grafted tomato plants were planted in the farmers fields in July 2006 (summer-rainy season). Soil amendment with poultry refuse and two hand weeding were also practiced.

Boteswar site of Norsingdi district. Plant mortalities of the grafted tomato varieties due to BW disease varied from 2.8% to 3.2% compared to 26.5% to 28.5% in the non-grafted varieties. Fruit bearing (avg. 25 fruits/plant) and fruit weight (avg. 37gms/fruit) in the grafted varieties were 139% and 133%, respectively, higher than that of the non-grafted varieties. As a result, the yields of the grafted varieties was 150% higher (17.2t/ha) than that of the non-grafted varieties (11.4t/ha).

Jamuna site of Gazipur: The performance of the grafted summer tomato cultivation was also highly encouraging at Jamuna village. The plant mortalities of the grafted tomato varieties due to BW disease averaged only 2.3% compared to 25% in the non-grafted varieties. Because of very low plant mortalities from BW, 146% higher fruit bearing (avg. 25 fruits/plant) and 130% heavier fruit weight (avg. 36gms/fruit), the yields of the grafted varieties were 147% higher (avg. 16t/ha) than that of the non-grafted varieties.

IPM package for higher and profitable production of cucurbit crops

The package consists of (a) Pheromone (Cuelure) in combination with mashed sweet gourd (MSG) bait trapping for fruit fly control; (b) Soil amendment with poultry refuse or mustard oil-cake for control soil-borne diseases; and (c) Two hand weeding. Results on yields and economic benefits were compared between IPM adopters and non-adopters. This package was practiced in two cropping periods during 2005-2006 at different villages of Jessore site in sweet gourd (pumpkin) and bitter gourd crops involving a total of 210 farmers and covering about 65ha (160 acres) of cropping land. In all the sites, the farmers were amazed to see the effectiveness of bait trapping in controlling fruit fly that helped produce much higher yields and fetch very high economic benefits as described below.

Sweet gourd crop during winter season (January-April, 2006): About 30 farmers in Gaidghat site adopted pheromone bait trapping in sweet gourd (pumpkin) in a total area of 5.2ha (12.9 acres). All the farmers practiced 2-3 hand weeding, but only a few practiced soil amendment with poultry refuse. Samples taken from five farmers showed that IPM adopters received 176% higher yield and 206% increased income than the non-IPM farmers who applied pesticides weekly or fortnightly.

Sweet gourd crop during summer season (June to November, 2006): About 40 farmers of several villages at Gaidghat site (Jessore) adopted pheromone bait trapping in sweet gourd (pumpkin) in a total area of about 16.4ha (40 acres). Fruit damage by the fruit flies averaged 5.9% in IPM fields compared to 36.8% in non-IPM fields that received weekly or fortnightly pesticide applications incurring 2.5 times more money for pest control purposes. As a result, the IPM adopters obtained about 203% higher yields and earned 198% higher profit than the non-IPM farmers.

Bitter gourd crop during summer season (March-October, 2006) at Nangarpur and Gaidghat: About 110 farmers adopted the bait trapping practice in about 32 ha (79acres) of bitter gourd crop at two sites of Nangarpur and Gaidghat. In IPM fields of Gaidghat fruit damage averaged 4.6% compared to 24.8 in non-IPM fields that received weekly applications of insecticides. Similarly, fruit fly damage in IPM fields at Nangarpur site averaged 6.8% compared to 29.5% in non-IPM fields. As a result of low fruit damage, the yields at Gaidghat and Nagarpur were 179% and 141% respectively, higher in profit. As compared to IPM farmers, the non-IPM farmers of Gaidghat and Nangarpur spent about 3 to 6.5 times more money for pest control purposes.

Bitter gourd crop during winter season (November 2005- April 2006) at Kachua site of Jessore Sadar: About 30 farmers adopted pheromone and MSG bait trapping (IPM practice) in about 13 ha of bitter crop at Kachua. As expected, fruit fly infestation in the IPM fields averaged only 3.2% compared to 38.6% in the non-IPM fields although the non-IPM farmers spent about 4.5 times more money for pest control purposes. As a result, the IPM farmers obtained 210% higher yields and as much net profit from adopting IPM practice.

IPM package for higher and profitable production of cabbage: This package consists of (a) Soil amendment with poultry refuse or mustard oil-cake for controlling soil-borne diseases; (b) Two hand weeding; and (c) Destruction of leaf-eating caterpillars of armyworm (*Spodoptera litura*) and Diamond-back moth (*Plutella xylostella*) by hand picking. This package was demonstrated in Nangarpur village (Jessore) in three farmers' fields during October-December, 2005 cropping season. During August-October, 2006 cropping period, 10 farmers adopted the IPM package in Nangarpur village and 8 farmers in Gaidghat village.

October-December, 2005 cropping season at Nangarpur: Infestation of the pests was low to moderate. The IPM adopters made only two hand-picking to destroy the caterpillars, whereas the non-IPM farmers applied insecticides 8-9 times during the 3-month cropping period incurring 8.4 times more money for pest control than the IPM adopters. In spite of frequent use of pesticides, the cabbage heads received 6.3% infestation in the non-IPM fields compared to only 3.4% in the IPM fields producing 111% more yield and bringing about 186% more profit to the IPM adopters than that of the non-IPM farmers.

August-October, 2006 cropping season at Nangarpur and Gaidghat: Infestation rates of the leaf-eating pests were low at both the locations; 2.1% to 4.5% in non-IPM fields and 1.6% to 5% in IPM fields. In spite of low infestations, the non-IPM farmers routinely applied insecticides fortnightly that cost them 3.6 times more money than the IPM adopters without increasing the yields. On the other hand, IPM fields produced higher yields and the IPM adopters received 112% higher profit than the non-IPM farmers.

IPM Technology Transfer by MCC (NGO)

The MCC concentrated their work mainly in Chandiara village of Chandina upazilla of Comilla district for dissemination of IPM package for fruit fly control in different cucurbit crops during December 2005-March 2006 and June-November 2006 cropping periods. In addition, MCC initiated small scale demonstrations for cultivation of grafted eggplant in eight districts in association with nine local NGOs.

IPM package for fruit fly control (December 2005-March 2006 cropping period): Forty farmers practiced pheromone bait trapping for fruit fly control in bitter gourd, sweet gourd and bottle gourd crops at Chandiara village of Chandina upazilla in Comilla district. Among other components of this IPM package, all the farmers weeded their fields 2-3 times, but only a few farmers used mustard oil-cake for soil amendment to control soil-borne disease pathogens.

Samples taken from five IPM adopters and five non-IPM farmers for each crop showed that IPM fields of all crops produced higher yields and brought about 2-3 times higher net profit for the farmers because of much lower fruit fly infestations and damage compared to the non-IPM fields. IPM fields of bitter gourd had 3.4% fruit fly infestation compared to 21% in non-IPM fields in spite of receiving 2-5 applications of insecticides. As a result, the yields in the IPM fields were higher fetching 242% higher net income to the farmers. In sweet gourd crop, fruit fly infestation in IPM fields averaged 4.8% compared to 25% in non-IPM fields that received 3-5 applications of insecticides. Because of very low fruit fly damage, the IPM fields produced higher yields and 197% higher net profit. Similarly, the IPM fields of bottle gourd had 3.8% fruit fly infestation compared to 20% in non-IPM fields in spite of receiving 3-4 applications of insecticides. The IPM fields brought about 242% higher income because of lower infestations and yields.

IPM package for fruit fly control (June-November 2006 cropping period): Twenty one farmers practiced pheromone bait trapping for fruit fly control in bitter gourd, sweet gourd and cucumber crops at Chandiara village of Chandina upazilla in Comilla district. None of the farmers practiced soil amendment for controlling soil-borne diseases.

Data on fruit fly infestation and economic returns were taken from five IPM fields and five non-IPM fields for each crop. In bitter gourd IPM fields, fruit fly infestation averaged 4.8% compared to 29% in non-IPM fields. IPM fields produced higher yields and fetched 149% more profit. Similarly, IPM fields of sweet gourd and cucumber crops had 3.8% and 4.2% fruit fly infestations compared to 20% and 18% infestations in non-IPM fields, respectively. As a result, the IPM fields produced higher yields and gave 176% and 260% more profits than the non-IPM fields.

Cultivation of grafted eggplant: In association with nine local NGOs, MCC initiated some demonstrations on cultivation of grafted eggplant in eight districts of Sirajganj, Bogra, Rangpur, Natore, Rangpur, Dinajpur, Tangail, and Comilla.

In Sirajganj in association of a local NGO (Social Work Center-SWC), 62 grafted eggplant seedlings were planted in the third week of June 2006. In spite of high plant mortalities from BW (due to wrong cultural practice), the grafted field produced 117% higher yield and 113% more income than the non-grafted field.

Training

Training of NGO Field Officers on IPM CRSP-BARI Technologies: IPM CRSP in collaboration with BARI and IRRI-Bangladesh organized 2-3-day training programs for the field officers of four NGOs on IPM technologies developed for vegetables by IPM CRSP-BARI.

Training Program for MCC Field Officers: A two-day **"**training of trainers" (ToT) program (May 24-25, 2006) was organized by IPM CRSP-BARI at MCC office in Sirajganj. IPM CRSP-BARI scientists acted as trainers. Twenty officers (7female & 14male) participated. They received theoretical training on seven IPM component technologies and four IPM packages for eggplant, tomato, cucurbit and cabbage crops. They also attended a half-day practical session on eggplant and tomato grafting. The trainees made 97 tomato grafts of which 61 (63%) survived and these were planted in the field of a local NGO.

IPM CRSP collaborators at BARI training.

Training Program for Field Officers of CARE-Bangladesh, Actionaid- Bangladesh, and Practical Action- Bangladesh: A three-day **"**training of trainers" (ToT) program (August 14-16, 2006) was organized by IPM CRSP-BARI and IRRI-Bangladesh at the Horticulture Research Center (HRC), BARI. IPM CRSP-BARI scientists acted as trainers. Twenty six officers (7female and 19male) of CARE-Bangladesh, Actionaid- Bangladesh, and Practical Action- Bangladesh participated in the program and they received theoretical training on seven IPM component technologies and four IPM packages for eggplant, tomato, cucurbit and cabbage crops. They also attended a half-day practical session on eggplant and tomato grafting, and setting up of pheromone bait traps in the field.

Later on, the Practical Action officers who received the IPM CRSP training imparted training to their field level officers, officers of partner NGOs (PNGO), and farmers on IPM practices in vegetables as well as training on vegetable production on commercial basis and at homestead. Thirty two persons (28 male and 4 female) received training on IPM practices, 126 persons (112 male & 14 female) on commercial vegetable production, and 331 persons (all female) on homestead vegetable production.

The trained field officers then oriented the IPM techniques at the farmer level and 21 farmers practiced soil amendment with mustard oil-cake for controlling seed-borne diseases in seedbed nurseries of cauliflower, cabbage, tomato and eggplant, and four farmers applied mustard oil-cake in the main planting field for growing red amaranth, mustard and garlic crops.

Similarly, the ActionAid officers who received the IPM CRSP training also oriented 61 of their field staff (42 male and 19 female) on IPM technologies. Later on, the trained field staff would train the farmers in six districts of Sunamganj, Noakhali, Patuakhali, Khulna, Satkhira, and Kurigram.

Farmer Training Program

IPM CRSP-BARI in collaboration with MCC and DISA (a local NGO) carried out a day-long IPM training in vegetables for 46 farmers and NGO officers (all male) at Chandiara village in Chandina upazilla (sub-district) of Comilla district on October 2, 2005. The farmers received theoretical training on different IPM CRSP-BARI technologies and they expressed high satisfaction. IPM CRSP-BARI scientists acted as trainers.

On October 3-4, 2005, the MCC officers who received IPM training imparted a two-day training to 46 farmers (43 male & 3 female) on vegetable IPM practices. Almost all the farmers who received training adopted IPM practices, mainly pheromone bait trapping for fruit fly control in cucurbit crops which are the main crops in the area.

USAID Funded PL480 Program on "Facilitating the Development and Spread of the Integrated Pest Management Collaborative Research Support Program".

This USAID funded three-year (2005-2007) program was approved by the Ministry of Agriculture of the Bangladesh Government in early 2005. The total cost of the project is Tk18.949 million (equivalent to about US$ 274,625; one US$=Tk69). Bangladesh Agricultural Research Council (BARC) is the executive agency to run the programs in collaboration with the Bangladesh Agricultural Research Institute (BARI) for testing of the vegetable IPM programs on wider scale and the Department of Agricultural Extension (DAE) for dissemination of the IPM technologies at the farm level. Although officially approved earlier, the actual work started from August, 2005.

BARI and DAE Technology Transfer Activities: The following technologies were targeted for demonstration in farmers' fields in two upazillas of each of the four districts of Jessore, Comilla, Narsingdi and Borga: (a) Eggplant grafting for bacterial wilt disease control; (b) Demonstration of pest-resistant eggplant varieties; (c) Sex-pheromone based management for eggplant FSB control; (d) Integrated approach for FSB, BW, and soil-borne pathogen control in eggplant; and (e) Fruit fly control by pheromone bait trapping in cucurbit crops.

Eggplant grafting for bacterial wilt disease control: 2200 grafted eggplant seedlings were raised for their planting in one location of Sadar upazilla and another in Manirampur upazilla of Jessore district. Similarly, eggplant grafting work was initiated for Comilla (8500 seedlings), Bogra (10,000 seedlings) and Narsingdi 11,000) sites.

Demonstration of pest-resistant eggplant varieties: As many as 2400 seedlings of pest-resistant eggplant varieties (BARI Begun-6 & 8) were distributed for Jessore sites. Seeds of the pest-resistant varieties were distributed for demonstration in other sites.

Sex-pheromone based management for eggplant FSB control: This IPM technology was established in all the sites. Along with sex pheromone, bio-control agents were also used and the results are very encouraging. Preliminary results showed that the FSB infestation in IPM fields averaged only 5%.

Integrated approach for FSB, BW, and soil-borne pathogen control in eggplant: Demonstration of this technology through soil amendment practice with poultry refuse, use of grafted eggplant and use of pheromone bait trapping have been initiated in all sites.

Fruit fly control by pheromone bait trapping in cucurbit crops: Planting of cucurbit crops was started in all sites. The use of soil amendment with poultry refuse, weekly removal of infested fruits and combined use of pheromone and MSG bate trapping will be started as soon as the crops start flowering.

BARI on-farm and on-station research activities: The following research activities were carried out in 2005-2006 period: (a) Integrated management of pests of eggplant and cucurbit crops; and (b) Cultivation of tomato lines resistant to whitefy and virus diseases. Both the activities were started at BARI farm, Gazipur and Jessore. The tomato lines that were included for the test are: TLB-111, TLB-130, TLB-133, TLB-182, BARI Tomato-2 (Ratan), and BARI Tomato-10 (Anupoma).

Marketing of Pesticide-free Vegetables

In collaboration with IPM CRSP and BARI, the Agricultural Technology Implementation Center (ATIC), a farmer participatory association located at Gaidghat site of Jessore district, signed an agreement with Jubak Agro-biotech Ltd (JAL), a private agricultural enterprise, to produce pesticide-free vegetables by using IPM CRSP-BARI technologies and the bio-agents produced by JAL. According to the agreement, JAL would purchase all the pesticide-free vegetables, at the farm gate, produced by the farmers at 15% premium price for marketing in the capital city of Dhaka. Presently, about 100 farmers of the area are engaged in producing various pesticide-free vegetables. Because of the economic incentives, more farmers are interested for participation in the contract. Starting from July 3 to August 11, 2006 (39 days), JAL lifted 27.2 tons of pesticide-free vegetables (15 kinds of vegetables) worth US$3,040 (Tk.2,09,772: Exchange rate 1US$=Tk.69).

Mutuality of Benefits of the Research

The pest problems assessed in these studies are common and widespread in Asia and also in other parts of the world. IPM approaches to manage these problems have broad applicability, especially in Asia. The cultivation and consumption of vegetables are growing in Bangladesh and the region. The primary feedback in terms of benefits to the United States will be through (a) the effects of economic growth in the region on trade and demand for U.S. products in international markets and (b) improved relations in a politically sensitive area of the world.

Technology Transfer in Albania

Douglas G. Pfeiffer, Site Chair, Virginia Tech
Josef Tedeschini, Site Coordinator, Plant Protection Institute, Durrës

Statement of Work:

IPM CRSP research in Albania has centered on olive pest management. One of the final activities of the project in Albania was a national olive symposium, which was very well attended. Toward the end of the final year of the project, a second PA was conducted. Its goal was to prioritize research needs in greenhouse tomatoes and cucumbers, as well as in vineyard and apple orchard systems. The PA revealed that large advances in apple IPM practices could be made with simple publications in Albanian, based on existing knowledge.

Technology transfer activities were carried out in cooperation with MoAFCP (Directory of Science and Extension Service, Plant Protection Sector), Plant Protection Institute (PPI), Fruit Tree Research Institute (FTRI), Vegetable & Potato Institute (VPI), Agricultural University of Tirana (AUT), Regional Advisory Center (RAC) and several regional departments of extension service were active participants in these training programs, in both organization of meetings and preparation of training materials.

Technology Transfer in Apple Orchards.

Local workshops

Activities relating to use of IPM packages to control pests and diseases in apple were organized in the two principle regions of apple production (in the northeastern and southeastern parts of Albania). In cooperation with Department of Agriculture of Dibra a workshop about the new technologies of cultivation and protection of apple crops was organized in Peshkopi. Thirty participants (farmers, extension officers and specialists of apple growing) from 14 villages attended this meeting. In this activity, participants were exposed to an overview of IPM and IPM CRSP activities and achievements in Albania, general principles and strategies of IPM, IPM in fruits and IPM in apple in particular.

Another local workshop in collaboration with Regional Advisory Center (RAC) was organized in Korçe region. Four presentations about the new techniques of apple cultivation, the benefits of intensive apple orchards and control of pests and diseases in new orchards were prepared by the specialists of RAC, PPI and AUT. Eighteen farmers and nursery stock producers mainly from the villages of Mollaj, Floq, Ravanik, Terove, Polene Zvezda, Dvoran, Drenove attended the meeting. All workshops were supplemented with printed materials.

Regional workshop

In collaboration with the Department of Extension Service of South East Albania a workshop was organized in Korçe region to demonstrate IPM systems to key apple farmers, technicians, producers and extension officers of the apple growing area. The theme of the workshop was “IPM in apple: New techniques for managing key pests”. A group of 17 participants from Pogradec, Korçe, Kolonje, attended the meeting and were trained in:

- Integrated Pest Management and how it can be practiced in apple production
- New techniques for monitoring the major apple pests
- New strategies for managing pests in the apple industry.
- Guidelines to control pests and diseases on apple according to EU/regulations.

The last workshop “IPM on Apple” was organized in Peshkopia in cooperation with Extension Service of Dibra. Twenty-five participants attended the meeting and four presentations on monitoring of key pests and diseases, new options for pest control were presented.

Technology Transfer on Vineyards

Regional workshop

In cooperation with Regional Extension Service of Berati a workshop on new techniques of cultivation and protection of vineyards was organized. This important activity attracted 34 farmers, technicians, extension officers, vine producers from 11 villages from the districts of Berati, Kucova and Skrapari, and served as an important vehicle for reporting IPM CRSP research and transferring IPM technology throughout the region. The specialists of PPI prepared six presentations and the participants were trained in:

- Arthropod pest status in vineyards
- Disease status in vineyards
- Integrated Pest Management and how it can be practiced in vineyard production
- Identification of major vineyard pests and its importance in pest management
- Management of mites in vineyards
- Guidelines on vineyards to control pests and diseases according to EU/regulations.

This workshop was organized in collaboration with "Movimondo" Project and in the presence of local authorities and local TV channels.

Local workshop

IPM CRSP collaborators of PPI together with the specialists of AUT and RAC offered a workshop on the use of new alternatives for pest and disease control in vineyards at Shkodra region, with the participation of 20 technicians, vineyard managers and vine producers from 7 villages. Five presentations were prepared about the real possibility of transferring IPM program in vineyards, about the monitoring of pests and diseases in vineyards, about new methods to control the pests and about the guidelines recommended by EU and especially about weed control.

Technology Transfer in Greenhouses

Regional workshop

With collaboration of Regional Extension Service Department of Berati a workshop was organized in Berati region. Eighteen technicians and specialists of greenhouses from Kuçova and Çorovoda attended the presentations prepared by the researches of PPI. The main topics of this activity were:

- New techniques of tomato pest monitoring in greenhouses
- New technique of nematode control.
- The possibility of using IPM package in greenhouses.
- Side-effects of different pesticides used in protected areas.

Another workshop was organized in collaboration with Regional Extension Services Department of Elbasani region. Twenty-five farmers, extension officers and other specialists attended the meeting and the topics presented by specialists of PPI and AUT dealt with monitoring of pests and diseases in protected areas, the possibilities of using biological control in greenhouses and a new technique (solarization) to control nematodes. The participants from Shushica, Bradashesh, Gostime, Kuqan, Katundi i Ri, Shtermen, Peqin, and Jogablen have received the materials prepared for this purpose.

The IPM CRSP collaborators have been in contact with RAC specialists to organize a regional workshop about the new technique of cultivation and protection of tomato and cucumber in greenhouses. For this purpose a workshop was organized in Fieri region. 21 farmers, technicians, vegetables producers and private agriculture advisers from the main region of greenhouses cultivation (Lushnje, Berati, Fieri, Durresi) participated in the workshop.

The last "IPM in Greenhouses" workshop was organized in Tirana in collaboration with Regional Extension Services Department of Tirana and Kavaja. New techniques pest and disease monitoring, pest status of cucumber and tomatoes under protected cultivation, techniques to control new pests were among the main topics. Twenty-seven participants, mainly from Petrela, Ndroqi, Krraba, Berzulla, Kavaja, Kamez, Petrela, Gosa, and Kryevidhe, attended the meeting and received the materials presenting proven IPM pest management strategies in greenhouses.

An Albanian olive farmer.

Technology Transfer in Olive

Regional workshop

In cooperation with FTRI and Regional Extension Service Departments of Berati and Vlora on a workshop on certified production of olive seedlings was organized in Vlora region. FTRI and PPI specialists prepared four presentations dealing with certified olive seedling production in Albania, about international rules of certification and about management of pests and diseases in olive nurseries.

Eighteen participants from Berati attended this activity and materials prepared for this purpose were distributed.

To improve the diffusion of the technology development of IPM CRSP/Al project, good progress was made in strengthening the relationships with other national and international organizations. For this reason a workshop was organized with the collaboration of SBCA (a project financed by USAID) in Ebasani region. Twenty-four farmers, olive oil processors, and other stakeholders from 12 villages attended the meeting and four presentations were made by specialists of PPI, AUT and RAC. The main topics were:

- New alternatives to control olive fruit fly
- Agricultural methods to control olive fruit fly (early harvest)
- Organic vegetation management of olive orchards
- Treatments to control olive leaf spot disease.

Technology Transfer of IPM Training and Capacity Building

Karim Maredia, Michigan State University

Development of Online/Distance Education Modules

Globally, the need for Integrated Pest Management (IPM) education is tremendous and growing. Building on the success of the International IPM course, MSU is developing on-line course modules in Agroecology, IPM and Sustainable Agriculture. The IPM information and course material accumulated during the past 10 years at MSU are serving as a starting point for the development of an on-line distance learning course in IPM.

Currently there is no on-line course module available with a focus on agroecology, IPM and Sustainable Agriculture. The on-line course modules would be a cost effective way of training a large number of IPM specialists around the world. This course will be a great training resource for professionals who can not be away from their work place for an extended period of time.

Short Course in Agroecology, IPM and Sustainable Agriculture

The Institute of International Agriculture at MSU has been offering a two-week short course in Agroecology, IPM and Sustainable Agriculture for the past 10 years. MSU will make this course available to IPM CRSP network in their efforts to build IPM capacity worldwide. Building on the success of the International IPM course, MSU will develop and offer an on-line course in IPM. This online course development will be completed in the third year and offered to the global IPM community through appropriate channels that have online course offering facilities.

Modules in development

Module 1: Introduction to concepts and principles of Agro ecology, IPM, and sustainable development: In this module the participants would become familiarized with the overall concepts of Agro ecology, IPM and Sustainable Development. This would allow the participants to take their depth of knowledge and see how it could apply to the three aforementioned topics.

Module 2: Production Ecology. This will enable to learner to put the different crops into a bigger picture of how the crop fits into the environment and the overall effects of input of the farmers on that system.

Module 3: IPM research approaches and methods. This would enable the participants to make informed decisions on how to develop on-site research plots as well as train farmers in order to have grower-led research plots.

Module 4: IPM Case Studies. Each case study would include success of IPM implementation, failure of the implementation, what changes could be made, and the overall approach to the IPM system.

Module 5: Information and training resources in Agro ecology, IPM and sustainable development. This would enable to participants to seek further education in IPM as well as give them direction in leading farmer field days.

An active input has been taken from the developing country participants in the design and content of the on-line modules. Several presentations of the International IPM short course at MSU have been video tapped and currently being edited. A discussion has been held to develop an on-line module of the regional IPM program on egg plant in South Asia as a case study.

Development of an Online Reporting System for IPM CRSP

Ron Skinner, North Carolina State University

Online Database

CIPM has developed and currently maintains an online management and reporting system for all IPM CRSP subcontracts. CIPM has developed the software, but the actual data entry and control are with VT. The backend database is MS SQL Server, but could be imported to any relational database. The middleware platform is Cold Fusion MX, running on MS Advanced Server. The choice of Cold Fusion allows the software to be run on any OS, with any major source data software.

The current system sits behind a commercial CISCO router/firewall with intrusion detection software. Redundant, RAID 5 web, database, and Cold Fusion servers are maintained. This system includes load balancers and is connected to an Internet II gigabyte loop.

It has been expanded to include a financial reporting system as well as a scientific reporting system. The completed financial reporting system includes the ability to upload/download invoices/budgets to/from the ME in Excel format.

The project reporting system is also essentially complete, with web-enabled access for all PIs and report generation capabilities for the ME. Within the next several months, the project will be completed by creating an executable of the software application set, extracting the database and data, and providing this system to the ME.

TRAINING AND CAPACITY BUILDING

Training and Institutional Capacity Development

Long-Term Degree Training

All IPM CRSP degree training is closely linked to research activities and aligned with project objectives. It engages long term degree training to strengthen the technical skills of research, teaching, and extension faculty from U.S. and host country Universities, National Agricultural Research Institutions, NGOs and other relevant organizations. While developing a global knowledge base in the U.S. Universities, it addresses specific host country IPM questions, opportunities, and constraints. The strength of the IPM CRSP's training program is the integration of training with long-term research carried out by the researchers based at the U.S. and host country universities. Since long term training is an integral part of the research program, an IPM CRSP researcher usually finds other sources of leveraged funds to partially support trainees.

- Six U.S. Universities and nine host country universities provided long-term training for 37 graduate students (18 Ph.D and 19 M.S) and five undergraduate students associated with IPM CRSP activities.
- Of these 42 students 37 are from developing countries and five from the U.S.
- Twenty eight are men and 14 are women.
- Their specializations in the graduate program are Agricultural Economics - 12, Crop Science/ Crop Protection - 5, Entomology - 5, Horticulture - 4, Plant Breeding -1, Plant Biotechnology -1, Plant Pathology -6, Plant Science - 2, and Plant Virology - 1.
- The number of trainees trained by regions is: Southeast Asia – 5, South Asia – 10, East Africa – 14, West Africa – 1, Eastern Europe – 1, Latin America and the Caribbean – 6 and USA – 5. (Table 1, and Appendix I)

Table 1: Long-Term Degree Training Participants by Country, FY 2006

Program	Doctorate		Masters'		Bachelors'		Total
	Men	Women	Men	Women	Men	Women	
Albania		1					1
Bangladesh	2	1	1				4
Chili				1			1
Ecuador			1				1
Ethiopia			1	1			2
Guatemala						1	1
Honduras					2		2
India	2	2	1				5
Indonesia	2						2
Jamaica				1			1
Kenya	1						1
Mali	1						1
Nepal			1				1
Philippines	1			2			3
Tanzania			2	1			3
Uganda	3		2	1	2		8
USA	1	1	2	1			5
Total	**13**	**5**	**11**	**8**	**4**	**1**	**42**

Short-Term Training

During the FY 2006, IPM CRSP held over 99 short-term training events serving more than 9420 persons. Training activities were held in 16 different developing countries with the host country collaborators active cooperation. These numbers were underreported because counts of the participating men and women were not recorded for all events. Thirty seven workshops, 18 meetings, 41 training sessions, one field day, and two farmers' field schools were held to impart various technologies to stakeholders (Table 2). Sex disaggregated counts were not made for all training events, however, in the Technology Transfer program of the Philippines, where the counts were fully recorded, indicated that the ratio for men: women was 3.4:1. The ratio of Bangladesh participants for men and women in the training program of Technology Transfer was 1: 1.4. The tilt towards a higher ratio of women participation was due to a workshop conducted on homestead vegetable production in which 331 women but no men attended. A full accounting of the training events is provided in the Appendix II.

Table 2: Short-Term Training Participants by Country, FY 2006

Country	**Men***	**Women***	**Total**
Albania	-	-	255
Bangladesh	310	385	695
Benin	-	-	140
Central Asia	4	2	6
Ukraine, Moldova	-	-	283
Ecuador	-	-	25
Ethiopia	28	1	29
Guatemala	1615	175	1790
Guinea	-	-	-
Honduras			166
India	25	10	35
Indonesia	-	-	75
Mali	-	-	20
Nepal	132	8	140
Philippines	1709	518	2290
Senegal	-	-	-
South Africa	1	-	1
Uganda, Kenya, Tanzania	-		3470
Total	**-**	**-**	**9420**

* Sex disaggregated counts were not made for all training events.

IPM CRSP Degree Training Participants (Graduate students): FY 2006

Student Name	Sex (M/F)	Nationality	Discipline	University	Degree	Start Date	End Date	IPM Program	Guide/ Advisor
Danida Pertena	F	Albania	Horticulture	Agricultural University of Tirana	PhD			East European Program	Doug Pfeiffer
A.K.M. Khorsheduzzaman	M	Bangladesh	Entomology	Bangabandhu Shiekh Mujibur Rahman Agricultural University	PhD	July 2003	June 2007	Technology transfer, Bangladesh	Zinnatul Alam
A.K.M. Salim Reza Mollik	M	Bangladesh	Horticulture	Bangabandhu Shiekh Mujibur Rahman Agricultural University	MS	Jul-03	May 2007	Technology transfer, Bangladesh	Mofazzal Hossain
Mossammat Shamsunnahar	F	Bangladesh	Plant Pathology	Bangabandhu Shiekh Mujibur Rahman Agricultural University	PhD	Mar-01	December 2006	Technology transfer, Bangladesh	Ismail Hossain Mian, Sally Miller
Faruque Zaman	M	Bangladesh	Entomology	Penn State University	PhD	August 2002	December 2006	South Asia Regional Program	Edwin Rajotte
Pilar Jano	F	Chile	Agricultural Economics	Virginia Tech	MS	2005	2007	Latin America and Caribbean Regional Program	Jeffrey Alwang
Robert Andrade	M	Ecuador	Agricultural Economics	Virginia Tech	MS	August 2006	June 2008	Latin America and Caribbean Regional Program	Jeffrey Alwang
Shashie Ayele	F	Ethiopia	Plant Science	Haramaya University	MS	2005	2007	Parthenium Global Program	Wondi Mersie
Asrese Hussen	M	Ethiopia	Plant Science	Haramaya University	MS	2006	2008	Parthenium Global Program	Wondi Mersie

Anitha Chiturri	F	India	Entomology	University of Georgia	PhD	January 2006	December 2006	Thrips-borne Tospoviruses Global Program	David G. Riley
Sudarsana Poojari	M	India	Plant Virology	Sri Venkateswara University	PhD	October 2006	September 2009	Thrips-borne Tospoviruses Global Program	Naidu Rayapati, K.S. Ravi, P Sreenivasulu
Atanu Rakshit	M	India	Agricultural Economics	Virginia Tech	MS	August 2005	June 2007	South Asia Regional Program, Impact Assessment Global Theme	George Norton
Rajwinder Singh	M	India	Entomology	Penn State University	PhD	September 2006	August 2009	South Asia Regional Program	Edwin Rajotte
S. Sivamani	F	India	Plant Biotechnology	Tamil Nadu Agricultural University	PhD	October 2006	September 2009	Thrips-borne Tospoviruses Global Program	Naidu Rayapati, K.S. Ravi, S. Krishnaveni
Ruly anwar	M	Indonesia	Entomology	Clemson University	PhD	August 2002	Sept. 2007	Southeast Asia Regional Program	Gerald Carner
Jackson Watung	M	Indonesia	Entomology	Sam Ratulangi University	PhD	August 2005	August 2008	Southeast Asia Regional Program	Dantje Sembel
Peta-Gaye Chang	F	Jamaica	Plant Pathology	Virginia Tech	MS	August 2005	August 2007	Insect Transmitted Viruses Global Program	Sue Tolin
Robert Geisimba	M	Kenya	Horticulture	Ohio State University	PhD	Sept. 2006	Aug.2008	East Africa Regional Program	D. Struve, R. Mulwa, Egerton
Moussa Noussourou	M	Mali	Plant Pathology	University of Mali	PhD	2003	Feb-07	Technology transfer, Mali	Larry Vaughan
Nagendra Subedi	M	Nepal	Plant Pathology	Ohio State University	MS	September 2006	August 2009	South Asia Regional Program	Sally Miller

Vida Alpuerto	F	Philippines	Agricultural Economics	Virginia Tech	MS	August 2006	June 2008	Impact Assesment Global Program	George Norton
Myra Clarisse Ferrer	F	Philippines	Applied Economics	Clemson University	MS	August 2006	August 2008	Southeast Asia Regional Program	Mike Hammig
Melanie Victoria	F	Philippines	Agricultural Economics	Virginia Tech	PhD	August 2005	March 2009	South Asia Regional Program	George Norton
Julita Bulali	F	Tanzania	Crop Science/ Crop Protection	Sokoine University	MS	March 2005	June 2007	East Africa Regional Program	A. Maerere
Fred Magina	M	Tanzania	Crop Science/ Crop Protection	Sokoine University	MS	Septe mber 2006	October 2008	East Africa Regional Program	A. Maerere
Hosea D. Mtui	M	Tanzania	Horticulture	Ohio State University	MS	Septe mber 2005	September 2007	East Africa Regional Program	A. Maerere, Mark Bennet
Godfrey Asea	M	Uganda	Plant Breeding	Ohio State University	PhD	August 2001	December 2005	East Africa Regional Program	Mark Erbaugh
Patrick Kucel	M	Uganda	Crop Protection	Makerere University	PhD	Octobe r 2006	September 2009	East Africa Regional Program	S. Kyamanywa, J. Ogwang, J Kovach
Sandra Ndagire Kamenya	F	Uganda	Plant Pathology	Makerere University	MS	Octobe r 2004	March 2007	East Africa Regional Program	Mark Erbaugh
Basil Mugonola	M	Uganda	Agricultural Economics	Virginia Tech	PhD	August 2006	July 2007	East Africa Regional Program	Dan Taylor
Annet Namuddu	F	Uganda	Crop Science/ Crop Protection	Makerere University	MS	June 2006	October 2008	East Africa Regional Program	S. Kyamanywa, G. Luther, J. Karungi

Ben Sekyanzi	M	Uganda	Crop Science/ Crop Protection	Makerere University	MS	Septe mber 2005	October 2007	East Africa Regional Program	G. Tusiime, P. Okori, G. Luther
Jessica Bayer	F	USA	Agricultural Economics	Virginia Tech	MS	August 2005	February 2007	Impact Assesment Global Program	George Norton
Jason Beddow	M	USA	Agricultural Economics	University of Minnesota	PhD	August 2005	February 2008	Impact Assesment Global Program	Philip Pardey
Steven Buck	M	USA	Agricultural Economics	Virginia Tech	MS	Januar y 2005	May 2006	Latin America and Caribbean Regional Program	Jeffrey Alwang
Michael Castellano	M	USA	Agricultural Economics	Virginia Tech	MS	August 2006	Jun-08	Latin America and Caribbean Regional Program	Jeffrey Alwang
Rachel Melnick	F	USA	Plant Pathology	Penn State University	PhD	Sept. 2006	December 2009	Latin America and Caribbean Regional Program	Paul Backman

IPM CRSP Degree Training Participants (Bachelor's Degree Students): FY 2006

Name of the Student	**Gender M/F**	**Program**
Norman Obed Delgado	M	Latin America and Caribbean Regional Program
Dennis Alvarez	M	Latin America and Caribbean Regional Program
Kenssy Bacca	F	Technology Transfer – Central America
Zachary Muwanga	M	East Africa Regional Program
Tom Omara	M	East Africa Regional Program

IPM CRSP Non-Degree Training, FY 2006

Program Type	Date	Training Type	Number of participants	Men	Women	Audience
South Asia – Regional Program						
Meeting	Mar.-06	Program planning meeting at BARI (Nepal)	3	3	-	Officials
Workshop	Aug.-06	National conference on IPM (Nepal)	131	124	7	IPM promoters
Meeting	Mar.-06	Cross project IPM meeting in Dhaka (Bangladesh)	7	7	-	Officials
Meeting	Mar.-06	Information sharing with professionals (Nepal)	6	5	1	IPM professionals
Southeast Asia – Regional Program						
Workshop	Aug. - 06	Establishment of communication systems (Indonesia)	35	25	10	Scientists and Collaborators
Meetings	May – Oct. - 06	Farmers Field Schools (Indonesia)	-	-	-	Farmers
Meetings	2006	Focus group discussions in Nueva Ecija (Philippines)	-	-	-	Women farmers
Workshops (7)	2005-06	Incorporation of predatory mite releases in the IPM system (Philippines)	-	-	-	Farmers
Radio Program (twice)	2006	Farmer-call-radio show in DZWT 540 (Philippines)	-	-	-	Farmers and public in Bagio city
Central Asia – Regional Program						
Training	May-June-2006	Barno Tashpulatova in biological control, Nurali Saidov in landscape ecology and Murat Aitmatov extension were trained at MSU and UC-Davis	3	2	1	Research Fellows
Short Course	June- 06	Nurali Saidov, Murat Aitmatov and Barno Tashpulatova attended the course on Agroecology, IPM and Sustainable Agriculture at MSU	3	2	1	Research Fellows
Eastern Europe – Regional Program						
Participatory	May - 06	Participatory appraisal in Ukraine and	13	-	-	Scientist and stake holders

Appraisal		Maldova				
Training course	Sep.-06	Tomato growing (Ukraine)	100	-	-	Unemployed individuals
Workshop	Sep.-06	Monitoring of the development of insects and diseases in apples and cucumbers	60	-	-	Farmers, instructors, plant protection workers and non-governmental organizations
Workshop	2006	Integrated plant protection system and organic agriculture	60	-	-	Farmers, instructors, plant protection workers and non-governmental organizations
Meeting	Nov. - 05	Pest and disease monitoring and forecasting	50	-	-	Plant Protection workers
East Africa – Regional Program						
Survey	May & Jun, - 06	Socioeconomic baseline survey – Coffee – Uganda	127	113	14	Coffee growers
Training	May – 06	Socioeconomic baseline survey training for regional teams	15	9	6	IPM teams from Kenya, Tanzania and Uganda
Workshop	May – 06	Biological monitoring program development	15	9	6	IPM teams from Kenya, Tanzania and Uganda
Survey	June & July – 06	Tomato growers, Kenya	120	97	23	Farmers
Survey	Jul. Aug. - 06	Tomato growers, Tanzania	100	67	33	Farmers
Survey	Sept. Oct. - 06	Tomato growers, Tanzania	-	-	-	
Workshop	Jun. – 06	Design of GIS research on agroecology of tomato fruit worm	3	3		Scientists
Training	June – 06	Biological control	-	-	-	Farmers
West Africa – Regional Program						
Meeting	Feb-Mar. - 06	Pesticide residue analysis –held in Bamako, Mali	-	-	-	Pesticide chemists
Meeting	Feb-Mar. - 06	Pesticide residue analysis – held in Dakar, Senegal	-	-	-	Pesticide chemists
Meeting	Mar. – 06	Participatory Planning Process held in Guinea	-	-	-	Scientists and collaborators
Workshop	Sept. – 06	Quality Assurance for Pesticide Residue Chemists	-	-	-	Pesticide chemists
Latin America and Caribbean- Regional Program						
Workshop	June - 06	Identificationn of economically importanat	25	-	-	Staff of INIAP stations

		insects				
Field Day	July - 06	Vegetable growing in Honduras	58	-	-	FHIA staff and vegetable growers
Information Technology – Global Theme						
Meeting	Marh-06	West Africa IPM consortium meeting	40	-	-	Scientists and host country collaborators
Meeting	Aug. – 06	Southeast Asia IPM planning meeting	30	-	-	Scientist and host country collaborators
Impact Assessment – Global Theme						
Workshop	May-06	IPM CRSP and ASBPII Impact studies, Mali	20	-	-	Scientists and collaborators
IPDN - Global Theme						
Training	June - 06	On plant disease diagnostics in Guatemala	20	-	-	Plant Pathologists from the region
Meeting	June- July-06	Stakeholder meeting in Guatemala	30	-	-	Scientists, collaborators and representatives from grower organizations
Meeting	Sept. – 06	Stakeholder meeting in Benin for West Africa	40	-	-	Scientists, collaborators and representatives from government organizations
Training	Sept. – 06	On plant disease diagnostics in Benin	40	-	-	Plant Pathologists and collaborators
Insect Transmitted Viruses – Global Theme						
Seminar	May-06	Insect transmitted viruses in crops	-	-	-	Collaborators and tomato industry representatives
Thrips-borne Tospoviruses – Global Theme						
Meeting	Feb.-06	Plant virus diseases	35	25	10	Scientists
Workshop	May -06	Tospovirus diseases	30	20	10	Scientists, vegetable see R&D
Parthenium Project – Global Theme						
Training and Workshop	May, June - 06	Practical training on biological control and weed biological control workshop in South Africa	1	1	0	Scientist from Ethiopia
Workshop	Dec.-05	Development of a plan and methodologies for the project	29	28	1	Scientists from Australia, Benin, Botswana, Ethiopia, India, Kenya, South Africa and USA

Technology transfer - Philippines						
Training	Dec. – 05	IPM in rice-vegetable cropping systems at Pasuquin, Ilocos Norte	52	37	15	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	May – 06	IPM in rice-vegetable cropping systems at Aritao, Nueva Vizcaya	89	65	24	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	May – 06	IPM in rice-vegetable cropping systems at Umingan, Pangasinan	76	60	16	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	June- 06	IPM in rice-vegetable cropping systems at Talavera, Nueva Ecija	91	69	22	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	June- 06	IPM in rice-vegetable cropping systems at San Jose City	78	58	20	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	June- 06	IPM in rice-vegetable cropping systems at Bongabon, Nueva Ecija	67	49	18	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	June- 06	IPM in rice-vegetable cropping systems at Rizal, Nueva Ecija	76	49	27	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	Aug. – 06	IPM in rice-vegetable cropping systems at San Vicente, Ilocos Sur	103	86	17	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	Aug. – 06	IPM in rice-vegetable cropping systems at Sta. Catalina	67	59	8	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	Aug. - 06	IPM in rice-vegetable cropping systems at Tagudin, Ilocos Sur	79	64	15	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	Sept.-06	IPM in rice-vegetable cropping systems at Sinait, Ilocos Sur	94	73	21	Farmers; village, federation, and municipal officials; and agricultural technicians
Training	Sept.-06	IPM in rice-vegetable cropping systems at Badoc, Ilocos Norte	97	73	24	Farmers; village, federation, and municipal officials; and

						agricultural technicians
Training of trainers	Aug. - 06	IPM in rice-vegetable cropping systems	38	21	17	Extension agents
Training	2005-06	VAM and *Trichoderma* mass production	814	625	189	Farmers and villagers
Training and practicum	Oct.- 05	VAM and *Trichoderma* production at Bongabon – Bantug	10	10	0	Farmers
Training and practicum	Oct.13, 05	VAM and *Trichoderma* production at Badoc	66	57	9	Farmers
Training and practicum	Oct. 26, 05	VAM and *Trichoderma* production at Badoc	22	22	0	Farmers
Training and practicum	Nov. - 05	VAM and *Trichoderma* production at Caaninaplahan, Campos	21	14	7	Farmers
Training and practicum	Nov. - 05	VAM and *Trichoderma* production at Sinait,Tubigay	22	21	1	Farmers
Training and practicum	Dec. - 05	VAM and *Trichoderma* production at Caaninaplahan, Pagasa	23	12	11	Farmers
Training and practicum	Jan. – 06	VAM and *Trichoderma* production at Pasuquin - DA	20	11	9	Farmers
Training and practicum	Feb. – 06	VAM and *Trichoderma* production at Sto. Domingo, Dolores	23	22	1	Farmers
Training and practicum	Feb. – 06	VAM and *Trichoderma* production at Sta. Catalina, Cabittaogan	14	12	2	Farmers
Training and practicum	June – 06	VAM and *Trichoderma* production at Bayubay	14	12	2	Farmers
Training and practicum	Aug. -06	VAM and *Trichoderma* production at Sto. Domingo, Dolores	5	5	0	Farmers
Training and practicum	Aug. -06	VAM and *Trichoderma* production at Tagudin Borono	57	45	12	Farmers
Training and practicum	Sept. – 06	VAM and *Trichoderma* production at Sinait, Purag	23	18	5	Farmers
Training and practicum	Sept. – 06	VAM and *Trichoderma* production at sinait, Calingayan	47	35	12	Farmers
Training and practicum	Sept. – 06	VAM and *Trichoderma* production at Badoc	39	35	4	Farmers
Technology transfer – East Africa						
Farmers Field		IPM technology of locally marketed crops	127	-	-	Farmers

School							
Training		Grafting egg plant	35	-	-	Farmers
Training of trainers		Pesticide applicator training	31	29	2	Extension agents and farmers
Training		Pesticide application	3000	-	-	Farmers and field workers
Technology transfer – Central America							
Meeting	Aug.-06	Management of the Melon Vine Collapse Issue in Southern Honduras during 2003-2006	50	47	3	Scientists, extension staff and farmers
Training the trainers	2005	Bagging fruits to prevent damage by fruit-fly in Guatemala	150	135	15	Trainers
Training	2005	Bagging fruits to prevent damage by fruit-fly in Guatemala	1500	1350	150	Farmers trained by the trainers
Meeting		Transfer of Fruit Bagging Technology for Guava and Star Fruit Production in Guatemala.	90	81	7	Extension staff and farmers
Workshop	July-06	Control of *Thrips tabaci* in onions	58	-	-	FHIA staff and farmers
Technology transfer - Albania							
Local Workshop		Pest and disease control in vineyards	20	-	-	Technicians, vineyard managers and vine producers
Workshop		New technologies of cultivation and protection of apple crops	30	-	-	Farmers and extension officers
Workshop		New techniques in apple growing	18	-	-	Farmers and nursery stock producers
Workshop		IPM in apple: New techniques for managing key pests	17	-	-	Farmers, technicians, and extension agents
Workshop		IPM on Apple	25	-	-	Farmers, technicians, and extension agents
Regional Workshop		Cultivation and protection of vineyards	34	-	-	Farmers, technicians, extension officers and vine producers
Regional Workshop		IPM for tomato production	8	-	-	Technicians and specialists of greenhouses
Regional Workshop		New techniques in tomato crop protection	25	-	-	Farmers and extension officers
Regional		Cultivation and protection of tomato	21	-	-	Farmers and technicians

Workshop						
Regional Workshop		Control of pests of tomato and cucumbers	27	-	-	Farmers
Workshop		Olive seedling production	18	-	-	Nurserymen
Workshop		Technology of olive production	12	-	-	Farmers and olive oil producers
South Asia – Bangladesh						
Workshop	May-06	Training of trainers in IPM for eggplant, cabbage, tomato and cucurbit crops	20	13	7	MCC Field officers
Workshop	Aug.-06	Training of trainers	26	19	7	CARE, Actionaid and Practical Action officers
Workshop	Aug.-06	Training ActionAid staff	61	42	19	Officers
Workshop	Aug.- 06	IPM practices in vegetable crops	32	28	4	NGOs and farmers
Workshop	Aug.-06	Commercial vegetable production	126	112	14	Farmers
Workshop	Aug.-06	Homestead vegetable production	331	0	331	Farm women
Workshop	Oct.-05	IPM training	46	46	0	Farmers
Workshop	Oct.-05	Training in fruit fly control	46	43	3	Farmers

IPM CRSP Non-Degree Training (Summary), FY 2006

Programs	Workshop	Training	Meeting	Survey	Radio	Field Day	Seminar	Classroom presentation
South Asia - Regional	1		3					
Southeast Asia - Regional	8		2		2			
Central Asia - Regional		2						
Eastern Europe - Regional	2	1	1	1				
East Africa - Regional	2	2		4				
West Africa - Regional	1		3					
Latin America and Caribbean - Regional	1					1		
Information Technology - Global			2					
Impact Assessment - Global	1							
IPDN - Global		2	2					
Insect Transmitted Viruses - Global							1	
Thrips-borne Viruses - Global	1		1					
Parthenium - global	1	1						
Technology Transfer Programs								
Philippines		29						
East Africa		3		1				1
Central America	2	2						
Albania	12							
Bangladesh	8							

IPM CRSP Publications, Presentations, and other Products, FY 2006

Refereed Publications:

AVRDC – The World Vegetable Center (2006). Plant protection activities at AVRDC – The World Vegetable Center. IAPPS Newsletter, No. IX, Sept 2006. *Crop Protection* 25 (2006) 1066-1068.

Erbaugh, J.M., P. Kibwika, and J. Donnermeyer. 2006. Assessing Extension Agent Knowledge and Training Needs to Improve IPM Dissemination in Uganda. Accepted for publication**.** Journal of International Agricultural and Extension Education.

Farrar, R. R., M. Shapiro, and Merle Shepard. 2005. Relative activity of baculoviruses of the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). BioControl. (accepted for publication).

Farrar, R. R., Jr., M. Shapiro and B. M. Shepard. 2005. Enhanced activity of the nucleopolyhedrovirus of the fall armyworm (Lepidoptera: Noctuidae) on Bt-transgenic and nontransgenic sweet corn with a fluorescent brightener and a feeding stimulant. Environmental Entomology. 34: 825-832.

Garrett, K. A., S.P. Dendy, E.E. Frank, M.N. Rouse, and S.E. Travers. 2006. Climate change effects on plant disease: Genomes to ecosystems. Annual Review of Phytopathology. 44: 489-509.

Garrett, K. A., S. H. Hulbert, J. E. Leach, and S. E. Travers. 2006. Ecological genomics and epidemiology. European Journal of Plant Pathology 115:35-51.

Geiser D.M., Ivey M.L., G.J. Hakiza, J.H. Juba, and S.A. Miller. 2005. *Gibberella xylarioides* (anamorph: *Fusarium xylarioides*) a causative agent of coffee wilt in Africa is a previously unrecognized member of the G. *fujikuroi* species complex. Mycologia 97 (1), pp. 191-201.

Gordon, S. G., P.E. Lipps, and R.C. Pratt. 2006. Heritability and components of resistance to *Cercospora zeae-maydis* derived from maize inbred VO613Y. Phytopathology 96:593-598.

Kaaya, A.N., H.L. Warren, S. Kyamanywa, W. Kyamuhangire. 2005. The effect of delayed harvest on moisture content, insect damage, moulds and aflatoxin contamination of maize in Mayuge district of Uganda. Jouranl of the Science of Food and Agriculture, Vol. 85, Issue 15, pages 2595-2599.

Lopez, R., A. Levi, B. Merle Shepard, A. M. Simmons, and D. M. Jackson. 2005. Sources of resistance to two-spotted spider mite (Acari: Tetranychidae) in *Citrullus* spp. HortScience, 40: 1661-1663.

Miller, S. A., T. M. Momol, S. A. Tolin, R. L. Gilbertson, F. Beed, D. Silue, M. A. Arevalo-Guerra, D. P. Maxwell, K. F. Cardwell. 2006. Development of the International Plant Diagnostic Network (IPDN): A multinational collaboration. Phytopathology 96:S79.

Momol, T. M., J. Xin, F. S. Zazueta, S. Zhang, R. F. Mizell, A. C. Hodges, H. W. Beck, S. A. Miller, W. Klassen. 2006. DDIS: A web-based distance diagnostic system for plant diseases and pests. Phytopathology, 96:S80.

Munyuli, M.B.T., S. Kyamanywa and G.C. Luther. 2006. Feeding behavior of ladybeetles on *Aphis craccivora* Koch (Homoptera: Aphididae) in Eastern and Central Africa. Indus Journal of Biological Sciences, 3: 578-585.

Munyuli, M.B.T., S. Kyamanywa, G.C. Luther and R. Hammond. 2006. Effects of groundnut genotypes, cropping systems and insecticide applications on the incidence of native arthropod parasitoids from Uganda and Democratic Republic of the Congo. Indus Journal of Plant Sciences. 5: 641-650.

Munyuli, M.B.T., G.C. Luther, and S. Kyamanywa (in press). Effects of cowpea cropping systems and insecticides on arthropod predators in Uganda and Democratic Republic of the Congo. *Crop Protection*, in press.

Munyuli, M.B.T., G.C. Luther and S. Kyamanywa. 2006. Predation effectiveness of syrphids (Diptera: Syrphidae) on *Aphis craccivora* Koch (Homoptera: Aphididae) in Eastern Africa. Indus Journal of Biological Sciences, 3: 596-603.

Smith, J. P. and B. M. Shepard. 2005. A binomial sequential sampling plan using a composite threshold for caterpillar management in fresh market collard. Journal of Agricultural and Urban Entomology, 21: 171-184.

Books/Book Chapters

Forbes, G. A., N. J. Grunwald, E. S. G. Mizubuti, J. L. Andrade-Piedra, and K. A. Garrett. 2006. (in review). Potato late blight in developing countries. In. R. Peters, (ed.) Current Concepts in Potato Disease Management. Research Signpost, Kerala, India.

Garrett, K. A., and C. M. Cox. 2006. Applied biodiversity science: Managing emerging diseases in agriculture and linked natural systems using ecological principles. In. R. Ostfeld, F. Keesing, V. Eviner (eds.) Cary Conference XI: Infectious disease ecology: the effects of ecosystems on disease and of disease on ecosystems. Princeton University Press.

Paçe, H. 2005. Menaxhimi i integruar i sëmundjeve në pemët frutore. Zjarri bacterial – *Erwinia amylovora*. [Integrated management of fire blight]. IPM CRSP/AL.114 p.

Pertena, D., E. Susaj, Sh. Shahini. E. Çota, V. Jovani, H. Paçe, J. Mërkuri and J. Tedeschini. 2005. Integrated vegetable production in greenhouses. IPM CRSP/AL. Plant Protection Institute. Durrës, Albania. 119 p.

Tedeschini, J. 2005. Menaxhimi i integruar i mizës së ullirit [Integrated management of olive furit fly]. IPM CRSP/AL. Plant Protection Institute. Durrës, Albania. 28 p.

Tedeschini, J., B. Stamo and D. Pfeiffer. 2006. Menaxhimi i paraziteve ne ullishtet organike. [Pest management in organic olives.] Plant Protection Institute. Durrës, Albania. 135 p.

Proceedings

Kamenya, S.N., G.J. Hakiza, G. Tusiime, B.B. McSpadden Gardener and R. Edema. (2006).

Kamenya, S.N., G.J. Hakiza, G. Tusiime, B.B. McSpadden Gardener and R. Edema. 2006. The potential of Ugandan isolates of fluorescent *Pseudomonads* for control of *Fusarium* wilt of coffee and Pythium bean root rot. African Crop Science Conference, Proceedings. 7:1257-1265.

Kangire, A., Kyetere, D., Erbaugh., M., Miller, S., Melanie, I., Geiser, D and Kabole, C (2005). Fusarium xylarioides is a specific pathogen that causes Coffee Wilt Disease (CWD) on robusta coffee in Uganda. African Crop Science Conference, Proceedings, Vol. 7. (in press).

Naidu, R.A. 2006. A global approach to tackle tospoviruses in vegetables: Challenges and opportunities, pp16-17. In: AVRDC. 2006. Proceedings of the 2006 APSA-AVRDC Workshop. 1-2 May 2006. AVRDC-The World Vegetable Center, Shanhua, Taiwan. AVRDC Publication 06-677. 22pp.

Strathie, L.W., A.R. Wood, C. van Rooi and A.J. McConnachie. 2005. *Parthenium hysterophorus* (Asteraceae) in southern Africa, and initiation of biological control against it in South Africa. In: Proceedings of Second International Conference on Parthenium Weed Management, 5-7 December 2005, Bangalore India. pp. 127 -133

Non-Refereed Publications:

Andrade, R., Barrera, V.H., Jeff Alwang and Agosto. 2006. Caracterización de las condiciones agro-socio-económicas de las familias productoras de naranjilla (Solanum quitoense) en la región Amazónica del Ecuador. Quito, Ecuador: INIAP

Jimenez, J. 2006. Plantas Injertadas de Berenjena Oriental: Una práctica para incrementar la producción de Berenjena oriental en Honduras.

Kharytonov, M. co-authored the following recommendations: Biological preparations and their effective application for vegetable and melon. Kiev, 2005 -12 p. (in Ukrainian)

Maslikova, K., M. Kharytonov and O. Lazareva. Tomato diseases and plant protection approaches. Agroview magazine, p.10-16, 2005, 26 Dec 2005 (in Ukrainian)

Rich, M. 2006. Pesky Virus Plagues Jamaican Peppers.

Strathie, L. And A. McConnachie. 2006. Weeds Division a key role-player in international collaborative project on management of parthenium in Africa. *Plant Protection News* 67: 12-13

Strathie, L. and A. McConnachie. 2006. Visit by Dr Mulugeta Negeri. *Plant Protection News* 68: 15

Strathie, L. 2006. PPRI Weeds Division a key role-player in international collaborative project on management of parthenium in Africa. *South African Weed Science Society Newsletter* 74: 2-4

Presentations

Alwang, J. 2006. Cost-effectiveness of Alternative IPM Technology Transfer Methods, Presentation to the 5th Annual National IPM Symposium, St. Louis.

Arevalo, M. 2006. Fungal diseases and nematode problems in the Central American region. IPM CRSP International Plant Diagnostic Network (IPDN) Training on New and Emerging Pathogens, Antigua, Guatemala, June 29, 2006.

Beed, F. 2006. Welcome to IITA-Bénin and Aims of Stakeholder Meeting and Training Workshop. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Bhanupriya, M., Sudarasana, P., Usha, Z. and Ravi, K.S. 2006. Characterization of Watermelon bud necrosis virus from Maharashtra. Poster presentation at International Symposium on Management of Vector-Borne Viruses at ICRISAT, Patancheru, Andhra Pradesh from 7-10th Feb. 2006.

Bhanupriya,.M., Sreenivasulu,.P., Usha, Z. and Ravi, K.S. 2006. Biological and molecular characterization of tospovirus isolates from India. Oral presentation at International Symposium on Management of Vector-Borne Viruses at ICRISAT, Patancheru, Andhra Pradesh from 7-10th Feb. 2006.

Boa, E. 2006. A means to an end: the Global Plant Clinic and primary plant healthcare. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Bonabana-Wabbi, J., Daniel B. Taylor, and Valentine Kasenge. 2006. A limited dependent variable analysis of Integrated Pest Management adoption in Uganda. Paper Presented at the American Agricultural Economics Association Annual Meetings, Long Beach, California.

Brewster, C.C. 2006. Regional pest management system for the whitefly in West Africa. On-site Participatory Planning Process Meeting, Kankan, Guinea.

Buck, S. 2006. The role of trust in knowledge acquisition and bank loan up-take: Results from field experiments in the Ecuadorian Amazon. OSU Brown Bag Seminar in Agricultural, Environmental & Development Economics Dept.; March 2006

Buck, S. 2006. Sustainable development and IPM Technology Transfer: A case study of Naranjilla farmers in the Ecuador. Thiel College Global Heritage Lecture; April 2006

Buck, S. and J. Alwang. 2006. The role of trust in knowledge acquisition: Results from field experiments in the Ecuadorian Amazon. American Agricultural Economics Association Meetings 2006, Long Beach, CA; July 2006

Buck, S. 2006. The role of trust in bank loan up-take: Results from field experiments in the Ecuadorian Amazon North Eastern Universities Development Consortium Conference 2006 at Cornell University; September 2006.

Clarendon, H. 2006. How do I know what I have and what does it matter if I know?. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Erbaugh, J.M., P. Kibwika, J. Donnermeyer. (2006). Assessing extension agent knowledge and training needs to improve IPM Dissemination in Uganda. Presented at the 22nd Annual Conference of AIAEE, May 14-18, 2006, Clearwater Beach, Florida.

Erbaugh, J.M. (2006). Developing IPM packages for small scale farmers in East Africa. Presented at the 5th National Integrated Pest Management Symposium, Delivering on a Promise, St.Louis, Missouri, April 4-6, 2006.

Erbaugh, J.M. (2005). IPM CRSP Uganda site research progress report. Presented at the Annual Meeting of the IPM CRSP, Blacksburg, Virginia. October 10-12, 2005.

Gilbert, J.R., G.W. Norton, J. Alwang, M. Miah, and G. Feder. 2006. Cost effectiveness of alternative extension methods: An example from Bangladesh, NC-1003 meeting, Jekll Island, Georgia, 40 participants.

Gilbert, J.R., G. W. Norton, J. Alwang, M. Miah, and G. Feder. 2006. Cost effectiveness of alternative extension methods: The case of Bangladesh," Presented at the 26th Conference of the International Association of Agricultural Economists, Gold Coast, Australia, August 15, 2006, 30 participants.

Gilbertson, R., L. Vaughan and A. Diarra. 2006. Links to other IPM-CRSP projects including West African Consortium of IPM Excellence. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Hamilton, S. 2006. Globalizing IPM: Participatory Research and Technology Transfer. Presented at the 5th National IPM Symposium, St. Louis, MO, Approximately 60-75 people attended the workshop.

Hamilton, S. 2006. Linking Participatory IPM Research and Technology Transfer: A Gender Analysis Platform. Paper presented at the workshop “Globalizing IPM: Participatory Research and Technology Transfer, 5th National IPM Symposium, St. Louis, MO, April 4, 2006.

Kovach and S.A. Miller. 2006, Provided a seminar on Bio-control of insects and diseases respectively, at Makerere University. The two seminars were well attended by 31 people (14 female). November 16, 2005

Kyamanywa, S. 2006. IPM Packages for cowpea in East Africa. Presented at the 5th National Integrated Pest Management Symposium, Delivering on a Promise, St.Louis, Missouri, April 4-6, 2006.

Luther, G.C. 2006. Integrated pest management technology transfer and adoption. Invited oral presentation at the 5th National IPM Symposium, 4-6 April 2006, St. Louis, USA.

Maredia, K. and D. Baributsa. 2006.USAID IPM-CRSP Regional Integrated Pest Management Centers, 5th National IPM Symposium. St. Louis, Missouri. April 6, 2006.

Mauceri, M., J. Alwang, G. Norton, and V. Barrera. 2006. Adoption of Integrated Pest Management Technologies: A case study of potato farmers in Carchi, Ecuador. Presented at the IAAE2006 meeting, Brisbane AU, August 15, 2006.

McDonald, S. and S. Tolin. 2005. *Uroleucon ambrosiae* and *Aphis nerii*: New vectors of Tobacco etch virus. Paper presented at the Annual Meeting of the Entomological Society of America, Fort Lauderdale, Florida, Dec. 15 – 18, 2005.

Miller, S. A. 2006. Introduction to the IPM CRSP and International Plant Diagnostic Network. IPM CRSP International Plant Diagnostic Network (IPDN) Stakeholder Meeting, Antigua, Guatemala, June 28, 2006.

Miller, S. A. 2006. Introduction to the IPM CRSP and International Plant Diagnostic Network. IPM CRSP International Plant Diagnostic Network (IPDN) Stakeholder Meeting, Antigua, Guatemala, June 28, 2006. Momol, T. The U.S. National Plant Diagnostic Network (NPDN). IPM CRSP International Plant Diagnostic Network (IPDN) Stakeholder Meeting, Antigua, Guatemala, June 28, 2006.

Miller, S. A. 2006. Background on the IPDN project. IPM CRSP International Plant Diagnostic Network (IPDN) Training on New and Emerging Pathogens, Antigua, Guatemala, June 29, 2006.

Miller, S. A. 2006. Bacterial disease diagnosis and ID. IPM CRSP International Plant Diagnostic Network (IPDN) Training on New and Emerging Pathogens, Antigua, Guatemala, June 29, 2006.

Miller, S. 2006. A. U.S. National Plant Diagnostic Network (NPDN) and International Plant Diagnostic Network (IPDN). International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Momal, T. 2006. The U.S. National Plant Diagnostic Network (NPDN). IPM CRSP International Plant Diagnostic Network (IPDN) stakeholder Meeting, Antigua, Guatemala, June 28, 2006

Momol, T. 2006. *Ralstonia solanacearum*, current diversity and management. IPM CRSP International Plant Diagnostic Network (IPDN) Training on New and Emerging Pathogens, Antigua, Guatemala, June 29, 2006.

Momol, T. 2006. Communication and Data Network Component of the IPDN. IPM CRSP International Plant Diagnostic Network (IPDN) Stakeholder Meeting, Antigua, Guatemala, June 28, 2006.

Naidu, R.A., K. S. Ravi, S. Adkins and D. J. Riley. 2006. Partnerships for Progress: India-US Collaboration for Integrated Management of Thrips-borne Tospoviruses in Vegetable Cropping Systems. Presentation at: Interactive Workshop on Plant Molecular Virology, February 11-12, 2006, Indian National Science Academy, New Delhi, India. (Sponsored by USAID, Indo-US Science & Technology Forum and Department of Biotechnology, Government of India).

Naidu, R.A., D. J. Riley, K. S. Ravi, C. Chaisuekeul and S. Adkins. 2006. Integrated Management of Thrips-Borne Tospoviruses in Vegetable Cropping Systems in South and Southeast Asia. 5th National Integrated Pest Management Symposium, April 4-6, 2006.

Naidu, R.A., S. Adkins, K.S. Ravi, P. Chiemsombat, R.K. Jain, H.S. Savithri, O. Gajanandana, V. Muniyappa, and D.J. Riley. 2005. Epidemiology of tospoviruses in South and Southeast Asia: Current status and future prospects. VIII International Symposium on Thysanoptera & Tospoviruses, Asilomar Conference Grounds, September 11-15, 2005. Abstracts, page 71.

Norton, G. W. 2005. Global Theme: Impact Assessment for the IPM CRSP," Technical Committee meeting, Blacksburg, VA, 30 participants.

Norton, G.W. 2006. Introduction: Is IPM Delivering? Economic Evidence from the U.S. and Abroad, presented at the 5th National IPM Symposium, St Louis MO, April 4, 100 participants.

Norton, G.W. 2006. Environmental benefits of IPM: Evidence from at home and abroad. Presented at the 5th National IPM Symposium, St Louis MO. 100 participants.

Norton, G.W. 2006. Evaluating the health, environmental, and socioeconomic impacts of IPM. Presented at the 5th National IPM Symposium, St Louis MO, 40 participants.

Norton, G.W. 2006. Impact assessment on the new IPM CRSP. Presented at the 5th National IPM Symposium, St Louis MO, 40 participants.

Norton, G.W. 2006. Impact assessment on the IPM CRSP. Presented at a meeting at USAID, Washington, DC, 30 participants.

Norton, G.W. 2006. Overview of IPM CRSP/ASBPII Impact studies in West Africa, presented at INSAH, Bamako, Mali, 20 participants.

Norton, G.W. 2006. Impact assessment on the New IPM CRSP. Presented at the IPM CRSP Board Meeting, June 15, Blacksburg, VA, 12 participants.

Norton, G.W. 2006. Assessing the impact of agricultural research: scope. Current Practice, Gaps, and Options. Presented at the 26th Conference of the International Association of Agricultural Economists, Gold Coast, Australia, August 14, 2006, 40 participants.

Norton, G.W. 2006. Applying a matrix framework to evaluate income. poverty, and environmental impacts of Agricultural R&D. Presented at the 26th Conference of the International Association of Agricultural Economists, Gold Coast, Australia, August 13, 2006, 50 participants.

Norton, G.W. 2006. Is IPM delivering on the promise: Introduction. Presentation to the 5th Annual National IPM Symposium, St. Louis.

Pfeiffer, D.G., A.D. Bratsch and J. Tedeschini. 2006. Participatory appraisal in expanding the Eastern European IPM CRSP. 5th National IPM Symposium, St. Louis MO. Apr. 4-6.

Rao, S., G. Carner, M. Shepard, S. Scott, M. Shapiro, D. Lynn, J. Becnel, and P. Mertens. 2006. Cypovirus identification by determining genome profiles with agarose gel electrophoresis: Correlation with sequence data. Annual Meeting of the South Carolina Entomological Society, McCormick, SC October 19, 20, 2006.

Reeder, R. 2006. New diseases from everywhere. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Roca, M. M., J. Brown, D. Maxwell, E. Aguilar, E. Flores, A. Rueda, M. Rivera, P. Jones, S. Ford, and R. Munford. 2006. Presence of viruses and fitoplasmas in tomato and other horticultural crops in Honduras, Nicaragua, El Salvador and Guatemala. Presented at the American Phytopathological Society Caribbean Division meeting, Cartegena, Colombia, September 2006.

Sadiov, N. 2006. Agricultural Landscape Management for Enhancing Biological Pest control (in Russian). August 30, 2006 Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan.

Sadiov, N. 2006. Biological Conservation through Habitat Management. Talk presented at the Regional Workshop on Assessing the importance of Colorado beetle and the emergence of new pest constraints in potato production system of Central Asia and the Caucasus in Tashkent. Organized by The International Potato Center CIP, Lima, Peru.

Shepard, B. M., 2006. Justifying international research to domestic stakeholders. Presented to the National Integrated Pest Management Conference. St. Louis, MO. April, 2006.

Shepard, B. M. 2006. Tospoviruses in vegetables in the Philippines and Indonesia Presented on behalf of Dr. Naidu Rayapadi at the IPM CRSPWorkshop in Ciloto, Indonesia. August, 2006.

Smith, J. 2006. Development of pest diagnostics and the provision and positioning of technical plant health services. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Strathie, L.W., and A. McConnachie. 2006. the storm around Demoina weed: investigating the distribution and Biocontrol of parthenium. 34th Annual Weeds Biological Control workshop, 22-26 May 2006. Klein Kariba, South Africa.

Tanzo, I.R. 2006. Women in agriculture: The case of pesticide management. Report presented at the University of the Philippines at Los Banos in celebration of Women's Month. March. Laguna, Philippines.

Tanzo, I.R. 2006. Women in Rice-Vegetables Pesticide Management. Paper presented at the 19th PhilRice Annual R&D Review. April. Philrice, Nueva Ecija.

Tanzo, I.R. 2006. Women in pesticide management: Assumptions and Realities. Paper presented at the 37th Annual Scientific Conference of the Pest Management Council of the Philipines. 2-5 May. Davao City, Philippines.

Tanzo, I.R. 2006. Gender issues in IPM. Report presented at the IPM CRSP Meeting. 7-11 August. Ciloto,Indonesia.

Tolin, S. 2006. Infrastructure standards for "ideal" Plant Disease Diagnostic Labs. IPM CRSP International Plant Diagnostic Network (IPDN) Stakeholder Meeting, Antigua, Guatemala, June 28, 2006.

Tolin, S. 2006. Serological approaches of plant virus ID. IPM CRSP International Plant Diagnostic Network (IPDN) Training on New and Emerging Pathogens, Antigua, Guatemala, June 29, 2006.

Tolin, S. A. 2006. Insect transmitted viruses. Presented in the Workshop "Implementing Ecologically-Based Participatory IPM in a Global Context: The New IPM CRSP", at the 5th National IPM Symposium, St. Louis, MO, April 4-6, 2006.

Tolin, S. A. 2006. Insect transmitted viruses: A Global Theme in the new IPM CRSP. A seminar presented at IDIAF in Santo Domingo, Dominican Republic, May 30, 2006, to collaborators and tomato industry representatives.

Vergot, P. 2006. IPDN data and communication network: topics for outreach training methods including web demonstration. International Plant Diagnostic Network (IPDN) West Africa: Stakeholder Meeting and Training Workshop, Cotonou, Benin, September 5-8, 2006.

Wood, S. 2006. The matrix revisited: Improving IA results, relevance, organization, and reporting. Presented at the 26th Conference of the International Association of Agricultural Economists, Gold Coast, Australia, August 13, 2006, 50 participants.

Xia, Y. 2006. IPM CRSP IT and Database Global Theme. IPM Symposium

Xia, Y. 2006. Goals and objectives of IPM CRSP IT Database global theme for West Africa. West Africa Regional IPM Consortium

Xia, Y. 2006. Goals and objectives of IPM CRSP IT Database global theme for Southeast Asia. Southeast Asia IPM CRSP Regional Program Planning Meeting

Xia, Y. 2006. CIPM Global IPM Database Efforts. China International Invasive Species Forum

Xia, Y. 2006. Outlines of IPM CRSP IT and Database Global Theme. USDA South Regional IPM Center Meeting.

Xia, Y. 2006. IPM Databases in global base. CIPM Semiannual Meeting

Conferences Attended

Maslikova Kateryna took part in the NATO ASI: Novel Biotechnologies for Biocontrol Agent Enhancement and Management. 8 Sep 2006 - 19 Sep 2006: Gualdo Tadino, Italy.

Websites Created

Dan Taylor, VT: **http://www.aaec.vt.edu/ipmcrspuganda/IPMCRSPEA**

Sally Miller, IPDN website: http://www.intpdn.org/

Yulu Xia, The Global IPM Technology Database:
http://www.ipmnetwork.net/

Yulu, Xia, West Africa Regional IPM Network
http://westafrica.ipmnetwork.net/

Yulu Xia, Southeast Asian IPM Network
http://seasia.ipmnetwork.net/
Albania: http://www.ento.vt.edu/Fruitfiles/Albania/AlbaniaIndex.html
Moldova: http://www.ento.vt.edu/Fruitfiles/Albania/MoldovaIndex.html

Ukraine: http://www.ento.vt.edu/Fruitfiles/Albania/UkraineIndex.html

Umbrella page (for Eastern European site):
http://www.ento.vt.edu/Fruitfiles/Albania/EasternEuropeIndex.html

Manuals

A grafting training manual has been produced in Luganda for Farmers. By Dr. R. Ssonko Namirembe

A manual for pesticide dealers and applicators on safe handling and application of pesticides by S. Kyamanywa, M. Otim, P. Okori, K. Jeninah & A. Agona

Brochures/Success Story Flyers

Erbaugh, M. 2006.Regional IPM Program for East Africa: Kenya, Tanzania, and Uganda.

Maredia, K. 2006. Ecologically-based Participatory and Collaborative Research and Capacity-Building in Integrated Pest Management in Central Asia.

Miller, S. 2006. Diagnosing Plant Diseases Benefits Farmers in Developing Countries.

Miller, S. 2006. Las Enfermedades de la Planta que Diagnostican Benefician a Granjeros en Países Reveladores.

Ramírez, D. 2006. Grafting Increases Production of Eggplant in Honduras.

Rayapati, A. Naidu. 2006. Solutions to Plant Viruses Improve Crop Management Strategies.

Tolin, S. 2006. IPM Combats Aphid and Whitefly-Transmitted Viruses in Developing Countries.

Theses

Norman, O. D. 2006. Effect of the orientation, number and type of nozzle of the spraying equipment used for the control of *Thrips tabaci* in onions with pesticides**.**Undergraduate thesis in Agronomy at the Private University of San Pedro Sula, Cortés, Honduras. 92 pp.

Buck, Steven. 2006. The Role of Trust in Knowledge Acquisition, Technology Adoption and Access to Bank Loans: Results from Field Experiments in the Ecuadorian Amazon. M.S. Thesis, Department of Agricultural and Applied Economics, Virginia Tech, April 24th, 2006, 113 pp.

Annual Reports

IPM CRSP annual report for the Year Twelve: 2004-05 (LAG-G-00-93-00053-00)
IPM CRSP annual report for the Year One: 2004-05 (EPP-A-00-04-00016-00)

Poster Presentation

Poster presented on disease resistance in the section *Lasiocarpa* to *Fusarium oxysporum* and additional potential of the section *Lasiocarpa* as a source of genes for naranjilla improvement, at the XII International Congress of Andean Crops held in Quito from 23-27 July, 2006

Technology Transfer

Presentations

Alcala, A V C., E. B. Gergon and M. B. Brown. 2006. Host efficiency of different plant species for mass production of VAM. Poster presented during the 37th Anniversary and Annual Scientific Conference of the Pest Management Council of the Philippines held in Davao City. May 2-5, 2006.

Clarke-Harris, D. 2006. IPM of Callaloo for meeting pre-clearance requirements for USDA-APHIS. Presented at 4 workshops in Jamaica.

Flowers, R. W., R. Quijije, A. Jines. 2006. II Curso – Taller Identificación taxonómica de insectos perjudiciales y benéficos. INIAP-Pichilingue. on CD.

Kyamanywa, S. (2006) IPM Packages for Cowpea in East Africa. Presented at the 5th National Integrated Pest Management Symposium, Delivering on a Promise, St.Louis, Missouri, April 4-6, 2006.

Luther, G.C. (2006). Integrated pest management technology transfer and adoption. Invited oral presentation at the 5th National IPM Symposium, 4-6 April 2006, St. Louis, USA..

Pfeiffer, D. G., A. D. Bratsch and J. Tedeschini. 2006. Participatory appraisal in expanding the Eastern European IPM CRSP. 5th National IPM Symposium, St. Louis MO. Apr. 4-6.

Rapusas, H. R. 2006. Past, present and future plans of the IPM CRSP-PhilRice in the Ecologically-Based Participatory IPM for Southeast Asia. Report presented at the Ecologically-Based Participatory IPM for Southeast Asia Project Workshop. August 8-10, 2006. Ciloto, West Java, Indonesia.

Rapusas, H. R. and S. Miller. 2006. Effective methods of transferring vegetable integrated pest management technology to farmers in Southeast Asia. Paper presented during the 5th National Integrated Pest Management Symposium. Adam's Mark, St. Louis, Missouri, USA. April 4-7, 2006.

Rapusas, H. R., K. T. Baroga, S. E. Santiago, J. M. Ramos and S. Miller. 2006. Transfer of rice-vegetable IPM technology to farmers in the Philippines. Paper presented during the 37th Anniversary and Annual Scientific Conference of the Pest Management Council of the Philippines (PMCP). May 2-5, 2006. Davao City, Philippines.

Santiago, S. E., H. R. Rapusas, J. M. Ramos, and G. S. Arida. 2006. Community-based implementation of IPM technologies in onion production. Poster presented during the 37th Anniversary and Annual Scientific Conference of the Pest Management Council of the Philippines (PMCP). May 2-5, 2006. Davao City, Philippines.

Shahini, Sh., E. Çota and E. Kullaj. 2005. Grape vine moth in Albania, 5th National Integrated Pest Management Symposium, St. Louis MO.

Weller, S. 2006. Feasibility and Effect of the Application of Mycorrhizae to the Melon Crop in a Soil with Natural Nutritional Levels", FHIA Annual Program Review, February 2-3, 2006, La Lima, Honduras. (50 attendees - 47 male and 3 female) "Results of Research on the Management of the Melon Vine Collapse Issue in Southern Honduras during 2003-2006", Presentation to AGROLIBANO and EXCOSUR, August 24, 2006, Choluteca, Honduras. (17 male attendees).

Weller, S. 2006. Transfer of Fruit Bagging Technology for Guava and Star Fruit Production in Guatemala". Presented by Danilo Dardon at ICTA'a Annual Research Review. ICTA Research Station, Barcena Villa Nueva. (90 attendees, 81 male and 9 female).

Publications: Non-Refereed

Robinah Ssonko Namirembe, Z. Muwanga, and T. Omara. 2006. Management of Bacterial Wilt of Tomatoes through Grafting onto Indigenous Resistant Rootstocks (in Luganda for Farmers). She has also developed a Teaching Aid video on grafting of tomatoes.

Kyamanywa, Sam, M. Otim, P. Okori and K. Jeninah. 2005. A manual for pesticide dealers and applicators on safe handling and application of pesticides. Crop Science Department, Faculty of Agriculture, Makerere University, Kampala, Uganda.

Field Guide on Insect Pests and Diseases in Onion-Rice Cropping Systems. 2006. PhilRice, Maligaya, Science City of Munoz, Nueva Ecija. 40pp.

Integrated Pest Management in Rice-Vegetable Cropping Systems. 2006. In Press.

Jimenez, J. 2006. Plantas Injertadas de Berenjena Oriental: Una practica para incrementar la produccion de Berenjena oriental en Hornduras.

Trichoderma: pangcontrol sa mga sakit ng sibuyas (Trichoderma to control diseases of onion) – PhilRice Broadcast Release. Vol. 6 No. 26.

Malago at mataas na ani ng gulay sa tulong ng kaibigang amag (high yield of vegetables with the help of a friendly fungus. PhilRice Broadcast Release. Vol. 6 No. 27.

Rich, M. 2006. Pesky virus plagues Jamaican Peppers.

Sex pheromone traps (Pilipino)- PhilRice Broadcast Release. Vol. 6 No. 28.

Manuals

Tedeschini, J. and E. Çota. Integrated Management of pests in vineyard".

Tedeschini, J. and H. Paçe. "Disease Management in Vineyards".

Brochures

Crop Profile-Tomatoes in greenhouse in Albanian and English language.

Crop Profile-Cucumber in greenhouse in Albanian and English language.

Fact Sheets

Clarke-Harris, D. 2006. IPM CRSP Technology Transfer Activities in Mavis Bank, St. Andrew.

Clarke-Harris, D. 2006. Training Sessions on Re-instating Callaloo on Pre-Clearance List.

Research on the Management of the Melon Vine Collapse in Southern Honduras (Investigacion sobre el Manejo del Colapso del Melon en el Sur de Honduras), 2006. Distributed to AGROLIBANO and EXCOSUR

IPM Snow Pea Planting, Teacher's Guide

IPM Snow Pea Planting, Student workbook

Protect Your Guava *Psidium guajaba L*. from Flies *Ceratitis capitata Whiedmann* and *Anastrepha spp*. Schner. (*Diptera:Tephritidae*). 2006. ICTA - Production manual available electronically and in hard copy.

Management of *Frankliniella occidentalis*, a new pest for Albania.

Management of fire-blight in apple orchards.

Management of whitefly in greenhouses.

Phomopsis viticola (Reddick) Goid a new disease for Albanian vineyards.

Posters

Tedeschini, J., B. Stamo and D.G. Pfeiffer. 2006. Integrated Pest Management package on olive fruit fly in Albania. 5th National Integrated Pest Management Symposium, St. Louis, MO.

Tedeschini, J., B. Stamo and D.G. Pfeiffer. 2006 The monitoring of olive moth (*Prays oleae* Bern) in Albania, loss assessment, and biocontrol with *Bacillus thuringiensis*. 5th National Integrated Pest Management Symposium, St. Louis, MO.

Huqi, B. Sh. Shahini and E. Kullaj. 2006 Evidence of weed and their integrated control in olive groves of Albania. 5th National Integrated Pest Management Symposium. St. Louis, MO.

Videos

Sex pheromones and sex pheromone traps.

Use and mass production of VAM – Vesicular Arbuscular Mycorhizae.

Use and mass production of Trichoderma sp (T5 ipm crsp isolate).

Grafting tomatoes.

Media Releases

Trichoderma: Pangcontrol sa mga sakit ng sibuyas (*Trichoderma* to control diseases of onions) – PhilRice Broadcast Release. Vol. 6. No. 26

Malago at mataas na ani ng gulay sa tulong ng kaibigang amag (High yield of vegetables with the help of a friendly fungus). PhilRice Broadcast Release. Vol. 6. No. 27.

Sex pheromone traps (Pilipino) – PhilRice Broadcast Release. Vol. 6. No. 28.

Features

PhilRice On Line: www.philrice.gov.ph

PhilRice bares how to control eggplant pests

IPM CRSP strikes rice-based Provinces

Reducing inputs in managing pests of onion grown after rice www.tagudin.gov.ph – News and Events http://www.tagudin.gov.ph/news.html

Tagudinian farmers attend confab. (The IPM CRSP – PhilRice in Coordination with LGU of Tagudin, Ilocos Sur conducted an intensive two day training/workshop on IPM on rice-vegetable cropping system for farmers and technicians).

News Articles

Use of sex urge to kill onion pests. The Philippines Star, 2005

Alternative IPM methods for rice-onion crops developed. The Philippine Star. January 28, 2006

Publications and Other Products of the IPM CRSP Compilation for the Year FY 2006 (Summary)

	Refereed articles	Non-refereed articles	Book Chapters	Proceedings	Web Sites	Workshops/ Training	Manuals	Brochures/ Fact sheets	Posters	Presentations
Latin America	0	1	0	0	0	2	0	0	1	8
East Africa	7	2	0	3	1	11	2	1	0	7
West Africa	0	0	0	0	0	4	0	1	0	1
Southeast Asia	7	0	2	0	0	4	0	0	0	7
South Asia	0	0	0	0	0	4	0	0	0	0
Central Asia	0	0	0	0	0	2	1	1	3	3
Eastern Europe	0	0	4	0	0	5	0	0	0	1
Parthenium	0	3	0	1	0	2	0	0	0	1
IPDN	3	0	0	0	1	4	0	0	0	14
Thrips - Virus	0	0	0	1	0	0	0	1	0	5
Insect - Virus	0	0	0	0	0	1	0	1	0	6
Information Technology	0	0	0	0	3	7	0	0	0	6
Impact Assessment	0	0	0	0	0	0	0	0	0	14
Central America	0	0	0	0	0	4	1	4	0	2
Caribbean	0	2	0	0	0	0	0	2	0	1
East Africa	0	2	0	0	0	4	0	0	0	2
Mali	0	0	0	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0	0	0	0
Philippines	0	6	0	0	0	29	0	0	0	5
Bangladesh	0	0	0	0	0	8	2	6	3	2
Albania	0	0	0	0	3	12	0	2	0	1
MSU	0	0	0	0	0	0	0	0	0	1
Ecuador	0	0	0	0	0	0	0	0	0	1

APPENDICES

Appendix A -List of Acronyms

AKI	Agricultural Knowledge Initiative
AMAREW	Amhara Micro-enterprise Development, Agricultural Research, Extension and Watershed Management
ANCAR	Agence Nationale de Conseil Agricole et Rurale, Sénégal
APEP	Agricultural Production Enhancement Project
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AUT	Agricultural University of Tirana, Albania
AVRDC	Asian Vegetable Research and Development Center/World Vegetable Center
ATC-RAS	Advisory Training Center of the Rural Advisory Services, Kyrgyzstan
BARI	Bangladesh Agricultural Research Institute
CAB I	Commonwealth Agricultural Bureau International
CEDEH	Experimental and Demonstration Center for Horticulture
CGIAR	Consortium for International Agricultural Research
CILSS	Comite Inter-Estate pour la Lutte contre la Sécheresse au Sahel
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CLSU	Central Luzon State University
CMV	Cucumber Mosaic Virus
CORI	Coffee Research Institute, Uganda
CPB	Cocoa Pod Borer
CSNV	Chrysanthemum Stem Necrosis Virus
CSB	Community Seed Bank
CU	Coordinating Unit
DAC	Direct Antigen Coating
DAC-ELISA	Direct Antigen Coating-Enzyme-Linked Immunosorbent Assay
DAI	Development Alternatives Inc.
DPPI	Degradable Polymer Products Incorporated
DPV	Direction de la Protection des Vegetau, Sénégal
EA	East Africa
EIAR	Ethiopian Institute for Agricultural Research
ELISA	Enzyme-Linked Immunosorbent Assays
ETQCL	Environmental Toxicology and Quality Control Laboratory, Mali
FAO	Food and Agricultural Organization
FFS	Farmers Field Schools
FGD	Focus Group Discussion
FHIA	Honduran Foundation for Agricultural Research
FIELD	Farmers Initiatives for Ecological Literacy and Democracy
FGD	Focus Group Discussion
FPE	Farmer participatory experiments
GIS	Geographical Information System
GPS	Global Positioning System
GTZ	German Technical Cooperation
IAPPS	International Association for Plant Protection Sciences
IARCs	International Agricultural Research Centers
ICARDA	International Center for Agricultural Research in the Dry Areas
ICADA	Central American Institute for Agricultural Development
ICIPE	International Center for Insect Physiology and Ecology
ICRAF	International Centre for Research in Agroforestry/ World Agroforestry Centre
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
ICTA	Institute of Agriculture Science and Technology
IER	Institut D'Economie Rurale, Mali
IITA	International Institute of Tropical Agriculture

INERA	l'institut de l'environnement et de researches agricoles, Burkino Faso
INSAH	Institut du Sahel
INSV	Impatiens Necrotic Spot Virus
INTECAP	Instituto Técnico de Capacitación
INTSORMIL CSRP	The International Sorghum and Millet Collaborative Research Support Program
IPB	Institut Pertanian Bogor (Bogor Agricultural University)
IPDN	International Plant Diagnostic Network
IPM CRSP	Integrated Pest Management Collaborative Research Support Program
IRAG	Institut du Recherche Agronomique de Guinée, Guinée
IRRI	International Rice Research Institute
ISA	Instituto Superior de Agricultura, Ecaudor
ISRA	Senegalese Institute for National Agricultural Research
IUCN	International Union for Conservation of Nature and Natural Resources
IYSV	Iris Yellow Spot Virus
KARI	Kenya Agricultural Research Institute
LAC	Latin America and Caribbean
MoAFCP	Directory of Science and Extension service, Albania
MU/FA	Makerere University Faculty of Agriculture
NGOs	Non-Governmental Organizations
OHVN	L'Office de alla Haute Vallée du Niger, Mali
PBNV	Peanut Bud Necrosis Virus
PCFV	Peanut Chlorotic Fanleaf Virus
PCR	Polymerase Chain Reaction
PPP	Participatory Planning Process
PSE	Pesticide Safety Education
PTM	Potato Tuber Moth
PYSV	Peanut Yellow Spot Virus
QDNR&M	Queensland Department of Natural Resources and Mines
QDS	Quarter Degree Square
RADHORT	Réseau Africain de Development de l'Horticulture, Sénégal
RC	Regional Coordinator
RCBD	Randomized Complete Block Design
RP/EA	Regional Program for East Africa
PYVMV	Pepper Yellow Vein Mali Virus
RTC	Regional Technical Committee
SAPIA	South African Plant Invaders Atlas
SeNPV	*Spodoptera exigua* Nuclear Polyhedrosis Virus
SUA	Sokoine University of Agriculture, Tanzania
TACRI	Tanzania Coffee Research Institute
TAS	Triple Antibody Sandwich
TEV	Tobacco Etch Virus
TLCMV	Tomato Leaf Curl Mali Virus
TMV	Tobacco Mosaic Virus
TNAU	Tamil Nadu Agricultural University
TSWV	Tomato Spotted Wilt Virus
TYFRV	Tomato Yellow Fruit Ring Virus
TYLCV	Tomato Yellow Leaf Curl Virus
TYLCMV	Tomato Yellow Leaf Curl Mali Virus
WBNV	Watermelon Bud Necrosis Virus
WSMoV	Watermelon Silver Mottle Virus
UC-D	University of California, Davis
UPLB	University of the Philippines at Los Banos
USDA/ APHIS	US Department of Agriculture, Animal and Plant Health Inspection Service
USDA/ARS	US Department of Agriculture/ Agricultural Research Service

Appendix B - Collaborating Institutions

U. S. Universities and NGOs

Clemson University Texas A&M University
Florida A&M University
Fort Valley State University
Kansas State University
Michigan State University
North Carolina A&M University
North Carolina State University
Ohio State University
Oregon State University
Pennsylvania State University
Purdue University
Tennessee State University
University of California-Davis
University of California-Riverside
University of Florida
University of Georgia
University of Minnesota
University of Wisconsin
US Department of Agriculture/ ARS
US Department of Agriculture/ ARS/Horticultural Research Laboratory
US Department of Agriculture, APHIS USDA/ARS Vegetable Crops Laboratory
US Department of Agriculture/ARS Sustainable Perennial Crops Laboratory
Virginia Polytechnic Institute and State University
Virginia State University
Washington State University
Winrock International

Non-U.S. Universities, Government Organizations and NGOs

Agence Nationale de Conseil Agricole et Rural, Sénégal
Agroexpertos, Guatemala
Amhara Regional Agricultural Research Institute, Ethiopia
Appropriate Technology Uganda Ltd
Bangladesh Agricultural Research Institute, Bangladesh Caribbean Agricultural Research and Development Institute
Center of Research and Ecotoxicology of the Sahel (CERES/Locustox Foundation, Senegal
Central Luzon State University
Centro para el Desarrollo Agropecuario y Forestal, Dominican Republic
Coffee Research Institute, Uganda
Commonwealth Agricultural Bureau International, England
Development Alternatives Inc. in North Sumatra, Indonesia
Direction de la Protection des Vegetau, Sénégal
Environmental Toxicology and Quality Control laboratory, Mali
FIELD Indonesia
Haramaya University, Ethiopia
Hasanuddin University in South Sulawesi, Indonesia
Honduran Foundation for Agricultural Research, Honduras
Human Resources Development Center, Tashkent, Uzbekistan
Indian Agricultural Research Institute, India
Institute D’Economie Rurale, Mali
Institut du Sahel, Mali
Institut de recherché agronomique de Guinée, Guinée
Instituto Centroamericano de Desarrollo Agropeuario

Instituto Dominicano de Investigaciones Agropecuario y Forestales, Dominican Republic
Instituto Nacional Autonomo de Investigaciones Agropecuarias, Ecuador
Institut Pertanian Bogor (Bogar Agricultural University), Indonesia
Institut Sénégalais de Recherches Agricoles, Sénégal
Kenyan Agricultural Research Institute, Kenya
L'institut de l'environnement et de researches agricoles, Burkina Faso
L'Office de la Haute Vallee du Niger, Mali
Makerere University, Uganda
National Agricultural Research Institute, Senegal
PhilRice, Philippines
Plant Protection Research Institute, South Africa
Programme de Developpement de la Production Agricole au Mali, Mali
Reseau African de Deveopment de l'Horticulture, Senegal
Samarkand Agricultural Institute, Uzbekistan
Sam Ratulangi University in Norht Sulawesi, Indonesia
Sokoine University of Agriculture, Tanzania
Sri Venkteswara University, India
Tamil Nadu Agricultural University, India
Tanzania Coffee Research Institute, Tanzania
Technical Cooperation Mission of Taiwan
Uganda National Agro-input dealers Association
University of the Philippines at Los Banos, Philippines
University of Queensland, Australia
University of Southern Mindanao, Philipppines
University of the West Indies, Trinidad
World Cocoa Foundation
World Conservation Union, Kenya
Zamarano School of Tropical Agriculture

IARCs

The World Vegetable Center (AVRDC)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
The International Institute of Tropical Agriculture (IITA)
International Rice Research Institute (IRRI)
International Food Policy Research Institute (IFPRI)
International Center for Agricultural Research in the Dry Areas (ICARDA)
International Center for Insect Physiology and Ecology (ICIPE)
International Potato Center (CIP)
The International Maize and Wheat Improvement Center (CIMMYT)

Private Sector

World Cocoa Foundation
Mahyco Research Center