Phase III - Year: 2007-2008

# The Integrated Pest Management Collaborative Research Support Program

# Annual Report

Management Entity for IPM CRSP: Office of International Research, Education, & Development (OIRED)
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Cover Photo: S.K. De Datta
IPM CRSP, OIRED, Virginia Tech, 2008

# Integrated Pest Management
# Collaborative Research Support Program
# FY 2008
# Annual Report

October 1, 2007 – September 30, 2008

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# Contents

# EXECUTIVE SUMMARY

The Integrated Pest Management Collaborative Research Support Program (IPM CRSP) is an initiative of USAID. It is a collaborative partnershipbetween the United States .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 Virginia Tech has been implementing the IPM CRSP project for the past 15 years with continuous support from USAID. It has brought together investigators from 22 U.S. universities and nine international agricultural research institutes, and scientists from over 30 countries comprising seven regions and five continents for the participatory IPM. There are seven regional programs and six global cross-cutting theme programs (Table 1).

## Regional Programs:

**Latin America and the Caribbean (LAC)**
**Crops for Broad-based Growth and Perennial Production for Fragile Ecosystems**
The LAC program is continuing to work successfully in several sites in Ecuador and Honduras. Major research results include identification of bio-based controls for pathogens and improved cultivation practices in mixed cocoa-plantain systems in Coastal Ecuador; completion of an IPM package for control of several prominent Andean fruit diseases; and testing and refining of a number of controls for pests and diseases in horticultural crops in Honduras. In Ecuador, a solid package exists for control of fusarium in production of naranjilla. Control of this disease will substantially increase incomes and reduce pressure on fragile erosive lands. In Honduras, hot water treatment of strawberry mites was further examined and found to be effective; soil solarization was confirmed to be effective for tomato and pepper beds and production of lettuce and beets; and promising alternatives to the control of purple nutsedge were investigated. In both countries, researchers are leveraging their funds with substantial external sources, and concerted efforts are being made to build linkages with extension service providers. In Honduras, FHIA and Zamorano are the main research partners linking with FINTRAC, an NGO that is creating strong linkages between producers and high-valued markets. In Ecuador, the research team has developed a cost-effective extension package for mixed plantain production. The LAC site has also undergone important south-south information and technology transfers and a process of impact evaluation has been established.

**East Africa**
**Regional IPM Program for East Africa: Kenya, Tanzania, and Uganda**
The two main complementary objectives of this program are to develop a regional model of collaborative IPM research, training, and knowledge dissemination that focuses on improving the productivity of higher-value marketed horticultural crops. Regional collaboration is fostered through the Regional Technical Committee (RTC) which is composed of one person from each country, the regional coordinator, the site chairperson, and USA-based technical experts as available.

The RTC met twice over the past year and research updates from the three countries were presented and critiqued, activity progress reports were presented by country, and management issues discussed. Additional activities that fostered regional collaboration over the past year included updating the regional program website portal; completion and write-up of socioeconomic baseline studies; completion of biological monitoring activities on tomatoes in all three countries and coffee in both Uganda and Tanzania; administration of disease incidence surveys on passion fruit in Kenya and Tanzania; continuation of on-farm/station trials in all three countries; completion of training programs for regional graduate students and graduate students in the U.S.; application of the regional modular IPM program for farmer/extension agent training at KARI/Thika; and implementation of a pesticide safety and usage program with KARI at the Kenyan research site inMwea. The regional program places great emphasis on capacity building and training activities in the region. Seven presentations and nine posters were presented at various international scientific meetings, and six regional scientific training programs were conducted in 2008. Seven papers were published or appeared in conference proceedings and nine other papers submitted to journals.

**SpacingWest Africa**
**Regional Consortium of Integrated Pest Management Excellence**
There are two major components of this program. One is to provide research-based information that can be used for insect and plant disease control. The other is to develop capabilities of quality assurance of crops that are destined for local consumption and also meet standards for export markets. The major research effort has been focused on controlling pests associated with tomato and potato production. Since whiteflies are a major insect problem due to their ability not only to impact crop health directly by feeding, but also because of their capacity as plant disease vectors, research efforts have been focused on learning about the seasonal and geographical distribution of whiteflies and their ability to transmit plant diseases among host plants including crops and weed species. This information is being incorporated into a geographical information system-based format for development of a model that can be used in predicting impacts of these pests on cropping systems. Also, varieties of tomato are being tested for their disease resistance that can be used as part of a pest management program. Potato production in West Africa is also affected by disease and insect problems including bacterial wilt and the potato tuber moth. Quality assurance issues are being addressed in two ways. The first is providing pesticide training to growers, whichincludes basic information on pesticide application procedures and safety issues. Instructional materials for use in the "training the trainers" program have been developed and are available in English, French, and two local languages. The second part of the quality assurance program includes the development of capabilities of regional pesticide residue laboratories. This effort has focused on improving the residue chemist's skills with new pesticide analytical methods as well as developing collaborative arrangements for these chemists to share information among the laboratories. The overall goal is to assist them in obtaining certification, enabling them to function as legal determinants for quality assurance of local and exportable crops.

**South Asia**
**Regional Integrated Pest Management Research and Education**
The South Asia Regional Program is based in Bangladesh with Nepal and India as satellite locations. This allows technologies and outreach methods that are successful in one country to be adopted by another country. In Bangladesh, 13 major research activities and five large technology transfer programs for farmers were completed. In Nepal, three technologies were imported from Bangladesh: namely mashed sweet gourd (MSG), soap-water, and grafting. Among them, the soap water trap used against fruit flies on cucurbits was highly successful in many project districts and is expected to replace poison traps. Scientists were successful in grafting desirable high- yielding varieties of tomato and eggplant as a scion to a native and wild plant from the Solanacae family that has tolerant characters to root knot nematode and bacterial and Fusarium wilt diseases. In India, the two primary collaborating institutions are Tamil Nadu Agricultural University (TNAU) and The Energy and Resources Institute (TERI). The three major activities at TNAU were conducting IPM trials with eggplant and okra, organizing training programs on grafting technology in tomatoes, and documenting insecticide resistance and population diversity in EFSB and whitefly. TERI held demonstration of IPM practices on eggplant, okra, tomato, and cucurbits at vegetable farms in five villages in UP, five villages in AP, and four villages in Karnataka.

**Southeast Asia**
**Ecology-Based Participatory Integrated Pest Management**
It involves seven sites in Indonesia and the Philippines. The unifying theme of all activities in these sites is to reduce farmers' reliance on chemical pesticides on vegetables and other high-value crops while maintaining the economic viability of their operations. Activities in West Java, Indonesia, where farmers are experimenting with biocontrol and natural fertilizers, are focused on IPM for cabbage, cucumber, green onion, and broccoli.. In North Sulawesi, IPM researchers are working on the use of local strains of *Trichoderma* for improved disease control, and biocontrol agents for insect pests have been beneficial for tomato, potato, and cabbage. In North Sumatra, FIELD/Indonesia works with farmers to improve vegetable and citrus systems.

In the Philippines, field studies were conducted to compare alternative IPM strategies and farmers' practices in managing pests infesting eggplant. IPM technologies to manage insects (fruit and shoot borer, leafhopper), diseases (bacterial wilt, phomopsis), and weeds (purple nutsedge, spiny amaranth) consisted of biological control methods (use of earwig, *Trichogramma*, *Trichoderma*), cultural methods (stale-seedbed technique) and host plant resistance (grafting of bacterial-wilt resistant cultivars to susceptible commercial cultivars). Farmer production and commercialization of VAM and *Trichoderma* have proven successful and PhilRice scientists provide technical support to these efforts. In Benguet Province, activities are focused on identifying and propagating predatory mites that feed on the spider mite pest.

**Central Asia**
**Ecologically-based Participatory and Collaborative Integrated Pest Management Research and Capacity Building Program**
Colonization and acclimatization of two predatory mite species under the laboratory conditions were carried out. The goal was to determine predator-prey ratio for efficient biological control of mites in vegetable crops and cotton in Central Asian agricultural landscapes. Landscape ecology research continued experiments on screening native and locally adapted flowering plants for their attractiveness to natural enemies of pests. Out of more than 50 locally collected plants screened, eight species of plants have shown potential for their use in agricultural landscapes for enhancing biological control. These eight plant species were evaluated for their agronomic characteristics and are currently being tested in strips planted in between wheat and cotton crops, and maize and vegetable crops in Tajikistan. The IPM outreach and education component focused on both academic and non-academic stakeholders through student field schools (SFS) and farmer field schools (FFS) in collaboration with NGOs, government institutes, and local universities in Tajikistan and Kyrgyzstan. A baseline socio-economic assessment was conducted in July 2008 through field visits to three countries in Central Asia.

**Eastern Europe**
**Integrated Pest Management of Specialty Crops in Eastern Europe**
The Eastern European project deals with several high-value horticultural crops: tomato, cucumber, grape, and apple. The participating countries are Albania, Moldova, and Ukraine. Research centered on vegetables in both protected and open settings. Basic IPM questions regarding phenology and sampling were addressed. Several other IPM areas were studied as well. Biopesticides and reduced risk pesticides were compared with conventional pesticides for the control of whiteflies, mites, leafminers, and aphids among the insect targets, and nematodes and soil-borne fungi and Botrytis among the pathogens. In addition, the cost efficiency of varying intensities of pesticide application was compared. Non-chemical approaches were included in our research as well. Albanian research includes soil solarization for the control of soil fungi and root-knot nematodes. This appears to be a very promising approach in Albanian greenhouses and plastic tunnels. Root grafting, or grafting commercial vegetable cultivars onto resistant rootstocks, was also evaluated to manage fungal and nematode problems on the roots of tomato and cucumber plants. In each region, workshops were held to introduce vegetable and fruit producers to IPM principles. An apple production and pest management book was published in Ukrainian to facilitate grower adoption of sound crop production practices.

# Global Theme Programs:

**Management of Parthenium**
CLIMEX modeling indicated that Ethiopia, Kenya, Somalia, Tanzania and Uganda in eastern Africa, and South Africa, Swaziland, and Mozambique in southern Africa as well as the south of Madagascar are ecoclimatically suitable for the growth and spread of *Parthenium hysterophorus.* Actual distributions determined during road surveys concurred with CLIMEX predictions, validating the model. Farmers in Ethiopia believe the invasion of parthenium weed causes a loss of income primarily; by reducing the yield of staple food crops such as sorghum; tainting milk and meat; and endangering the health of their livestock. Species diversity and evenness declined with the increasing density of parthenium in the standing vegetation and soil seed bank flora both in sorghum fields and grazing lands. Parthenium was found to be the most dominant weed in sorghum fields with 12%, 31%, and 59% of cover abundance in low, moderate, and high infestation levels, respectively. Host specificity studies of the natural enemies, *Listronotus setosipennis* and *Zygogramma bicolorata* are continuing in the quarantine facilities in South Africa and Ethiopia. No *L. setosipennis* progeny were produced on the 19 species of plants tested. No-choice tests with *Z. bicolorata* on 38 native and economically important plant species indicated that some, including several sunflower varieties, were accepted for feeding and oviposition, however, no larvae developed from eggs laid on these species.

**International Plant Diagnostics Network**
The International Plant Diagnostics Network (IPDN) continues to establish itself in three regions: East Africa, West Africa, and Central America. The IPDN is approaching the classic definition of a network: a system of individuals or groups that are distributed widely, communicate with one another, and work together. Most of the communication

amongst network members takes place on a regional level, but communications amongst group leaders on a global scale is encouraged. The network is held together by a common goal – to increase capacity for plant disease and insect pest diagnostics in developing countries. Members work together to develop and participate in training programs (share expertise), develop standardized diagnostic methods, prioritize pathogen and pest problems, and consult with one another through a diagnostics web portal developed by the project. This web portal, the Distance Diagnostic and Identification System/Clinic Information Management System (DDIS/CIMS), was released (beta version) and tested in all three regions. U.S. training in the use of the DDIS/CIMS was conducted in East Africa and Central America for 59 individuals. Participants were also trained in plant and insect pest diagnostic techniques, including modern methods such as serology and PCR.

**Thrips-borne Tospoviruses**

Thrips-transmitted tospoviruses are a significant constraint to the production of quality vegetables in South and Southeast Asian countries. The project is conducting strategic research to generate science-based knowledge on different aspects of tospoviruses and thrips vectors occurring in major vegetable crops in smallholder agriculture, and to develop methods for accurate detection of viruses and thrips vectors. The project placed special emphasis on capacity building in developing countries through graduate education and short- and long-term training in plant virology and entomology. The project placed an explicit commitment to the gender mainstreaming strategy in capacity building and outreach activities because gender equality has a great anti-poverty affect on growth. Outreach activities were conducted in different places in India to draw awareness to virus disease problems in vegetable crops.

**Insect Transmitted Virus Diseases**

This program was established to address viruses that infect vegetable crops, mainly of the Solanaceae and Cucurbitaceae, and that are transmitted by aphid and whitefly vectors. Information on all known viruses and their vectors on these crops, as well as those identified in participating host countries, has been compiled. The project has assisted in improving the diagnostic capability of key laboratories in all host countries through facility improvement and technology development and transfer, and has also identified viruses in U.S. and AVRDC laboratories by serological and molecular detection and sequencing techniques. Several identifications are new virus species or strains. Advanced degree and short-term training have been conducted to build in-country capacity in diagnosis, needed monitor virus and vector pressure, and design and test efficacy of management practices. Host-free periods to reduce incidence of whitefly transmitted begomoviruses have been effective in parts of the Dominican Republic and continue to be monitored. Monitoring whitefly species and the virus load in them has been initiated in Guatemala with weekly count data made web-accessible to growers in the Salamá Valley. Appraisals of virus ecology and temporal and spatial dynamics of aphid and whitefly vector species and populations are being conducted in several countries in order to design IPM approaches. Both local vegetable crop varieties and breeding lines from AVRDC are being evaluated for their response to viruses with the objective of improving genetic resistance. In all host countries, stakeholder groups and growers are being engaged to explain viral diseases and approaches to diminish losses.

**Information Technology and Database**

This global theme is collaboratingwith the Southeast Asia regional program on the development of a Cocoa Pod Borer (CPB) database. It is also working with the West Africa regional program on a whitefly database, and the Latin America and the Caribbean program in developing a National Pest Information System for Ecuador. The host countries involved include: Mali, Ecuador, Jamaica, and Indonesia. Additionally, a Global IPM Technology Database, Fruit Fly Pest Watch, and PestMapper are being developed.

**Impact Assessment of the IPM CRSP Programs**

One graduate student at Virginia Tech completed his M.S. thesis examining the impacts of the pheromone IPM research in Bangladesh. Working with a second student at Virginia Tech, a review of previous impact assessments on the IPM CRSP was conducted and new impact analyses were started for plantain in Ecuador, and tomatoes in Uganda and Albania. An overall impact assessment report is near completion. Collaborating with scientists at the Latin American site, a four- day workshop on economic and social impact assessment was held at Zamorano in Honduras with 20 participating scientists from Honduras, El Salvador, Nicaragua, and Ecuador. Researchers at the University of Minnesota and at IFPRI, together with a Ph.D. student at the University of Minnesota, developed 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. An online survey method and practical tool that allows for rapid and distributed collection of spatial pest and disease occurrence data has been developed. The result of this effort is the V-GET (Virtual Geo-referenced Elicitation Tool) platform. The V-GET surveying approach aims to collect sufficient data across a globally representative agro-ecological gradient to enable accurate calibration of a spatial pest occurrence simulation program (CLIMEX). After deliberations with pathologists, entomologists, agronomists, and other scientists, a target list of survey pests and diseases was compiled. A series of international surveys on the spatially-explicit occurrence of specific insects and diseases is underway with the cooperation of co-survey leaders based at CIMMYT, CIAT, IRRI, and CSIRO.

**Program Impact Areas:**

IPM CRSP FY 2008 activities have produced the following outputs:

**Long-Term Projects**

- 62 -- Long-term degree students (38 men and 24 women)
- 12,398 -- Short-term training participants
- 39 – Workshops
- 22 – Meetings
- 24 – Training sessions
- 61 – Field days/Demonstrations/Exhibitions
- 6 – Seminars/Symposiums/Conferences
- 66 – Poster Presentations
- 104 – Publications
- 59 – Abstracts
- 48 – Presentations
- 15 -- Posters
- 1 -- Annual report

**Training and Institutional Development**

IPM CRSP research activities contributed to short- and long-term training. Sixty-two students from 20 countries were involved in long-term degree training. Of these, 56 were from developing countries and six were from the U.S. There were 50 men and 37 women students who were working in 27 Ph.D., 35 M.S., and 27 B.S. degree programs. Graduate students were majoring in agriculture (9), agricultural economics (10), plant pathology (10), entomology (8), crop science/ crop protection (6), horticulture (3), plant virology (2) gender issues (1), integrated pest management (1), plant biotechnology (1), and weed science (1), applied economics (1), geography (1), insect pathology (1).

**Table 1. List of Programs, Host Countries, Investigators, and Participating Institutions.**

| Project Title | Host Countries | Principal Investigator | Co-Investigators | Host Country Collaborators | Participating institutions |
|---|---|---|---|---|---|
| IPM in Latin America and the Caribbean | Ecuador, Honduras | Jeff Alwang | Sally Hamilton, Stephen Weller, Paul Backman, Wills Flowers | Carmen Suarez-Capello Mauricio Rivera, Alfredo Rueda, Danilo Vera, | Virginia Tech, Pennsylvania State University, Florida A&M University, Purdue University, Zamarano, FHIA |
| Regional IPM for East Africa | Uganda, Kenya, Tanzania | Mark Erbaugh | Dan Taylor, Sally Miller, J. Kovach | Samuel Kyamanywa, Monica Waiganjo, Amon Maerere, K. Sibuga | The Ohio State University, Virginia Tech, AVRDC, Makerere University Faculty of Agriculture (Uganda), Kenya Agricultural Research Institute, Sokoine University of Agriculture (Tanzania), National Agricultural Research Organization and Coffee Research Institute (Uganda), Egerton University (Kenya), Tanzania Coffee Research Institute |
| West African Regional Consortium of IPM Excellence | Burkina Faso, Guinea, The Gambia, Mali, Senegal | Donald Mullins | Carlyle Brewster, Jean Cobb, Pat Hipkins Jim Westwood, George Mbata, Yulu Xia, Bob Gilbertson, Rich Foster | Amadou Diarra, Kadiatou Toure Gamby, Kemo Badji, Abderhamane Issoufou Kollo, | Virginia Tech, AVRDC, Fort Valley State University, University of California-Davis, Purdue Univesity, INSAH, ANCAR, CERES Locustox, DPV, ETQCL, IER, IITA, INERA, IRAG, ISRA, NARI, OHVN |
| Regional IPM Research and Education for South Asia | Bangladesh, India, Nepal | Ed Rajotte, George Norton | E.A. Heinrichs, Sally Miller | Rezaul Karim, Nutan Kaushik, V. Balasubramani, B.Y. Gywali, Luke Colavito, R. Srinivasan | Pennsylvania State University, Virginia Tech, IRRI, AVRDC, The Ohio State University, Bangladesh Agricultural Research Institute, and Tamil Nadu Agricultural University and The Energy and Resources Institute (India) |
| Ecologically Based Participatory IPM for Southeast Asia | Indonesia, Philippines | Michael Hammig | Merle Shepard, Gerry Carner, Karen Garrett, Beverly Gerdeman, Naidu Rayapati, Yulu Xia | Aunu Rauf, Dantje Sembel, Russell Dilts, Peter Ooi, Greg Luther, Nugroho Weinarto, Aurora Baltazar, Herminia Rapusas, Casiana Vera Cruz | Clemson University, Washington State University, Kansas State University, Bogor Agricultural University (Indonesia), Sam Ratulongi University (Indonesia), PhilRice, University of the Philippines at Los Banos, IRRI |
| Ecologically Based Participatory IPM in the Central Asia Region | Kyrgyzstan, Tajikistan, Uzbekistan | Karim Maredia | Douglas Landis, George Bird, Walter Pett, Frank Zalom, Dieudonne Baributsa | Nurali Saidov, Murat Aitmatov, Barno Tashpulatova, Mustapha El-Bouhssini | Michigan State University, University of California – Davis, ICARDA |

| | | | | | |
|---|---|---|---|---|---|
| IPM of Specialty Crops in Eastern Europe | Albania, Moldova, Ukraine | Doug Pfeiffer | Sally Miller, Tony Bratsch, Milt McGiffen | Josef Tedeschini, Vladimir Todirach, Olena Cholavska, Nicolay Kharytonov | Virginia Tech, The Ohio State University, University of California - Riverside |
| Management of the Weed Parthenium | Botswana, Ethiopia, Kenya, Uganda, South Africa | Wondi Mersie | | Lulseged Gebrehiwot, Lorraine Strathie, Andrew McConnachie, Arnie Witt, Kassahun Zewdie, Mohammed Dawd, Lisanework Nigatu | Virginia State University, Ethiopian Institute of Agricultural Research, Plant Protection Research Institute-South Africa, Plant Protection Research Institute- Queensland-Australia, Haramaya University |
| International Plant Diagnostic Network | West Africa, East Africa, Central America | Sally Miller | Sue Tolin, Carrie Harmon, T. Momol, Bob Gilbertson, D. Maxwell, J. Mera | Fen Beed, M. Arevalo, Zachary Kinyua | The Ohio State University, Virginia Tech, University of Florida, University of California – Davis, AgroExpertos-Guatemala, IITA, KARI-Kenya, USDA-APHIS, Makarere University |
| Management of Thrips Borne Tospoviruses | India, Indonesia, Uganda, Tejikistan | Naidu Rayapati | David Riley, Scott Adkins, Peter Hanson, M. Hammig, M. Erbaugh, K. Maredia | G. Karthikeyan, Gopinath Koditham, Tri Damayanti, M.K.N. Ochwo-Ssemakula, Zarifa Kadirova | Washington State University, University of Georgia, USDA-ARS, Tamil Nadu Agricultural University, University of Hyderabad, Bogor Agricultural University, Makerere University |
| Integrated Management of Insect Transmitted Viruses | Guatemala, Jamaica, Burkina Faso, Mali, Honduras, Dominican Republic | Sue Tolin | Judy Brown, Bob Gilbertson, C.M. Deom, Yulu Xia, Naidu Rayapati, Don Mullins | Sharon McDonald, M. Palmieri, M. Rivera, S. Green, W. McLaughlin | Virginia Tech, University of Arizona, University of California-Davis, North Carolina State University, Washington State University, University of West Indies, IITA, AVRDC |
| Application of Information Technology and Databases | Mali, Jamaica, Indonesia, Ecuador | Yulu Xia | Ron Stinner, Don Mullins, Mike Hammig, Jeff Alwang, S. Fleischer | P. Chung, Danilo Vera, Carmen Suarez-Capello | North Carolina State University, Virginia Tech, Penn State University, Clemson University, RADA-Jamaica, Crop Protection Department-Ecuador |
| IPM Impact Assessment for the IPM CRSP | All countries involved in the IPM CRSP | George Norton | Stanley Wood, Philip Pardey | PI's and collaborators | Virginia Tech, University of Minnesota, IFPRI, CIMMYT, CIAT, IRRI, and CSIRO |

# PHASE III LONG-TERM

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

*Jeff Alwang, VirginiaTech*

**Co-Investigators:**
Sephen Weller, Purdue University
Paul Backman, Penn State University
Wills Flowers, Florida A&M Univesity
**Host Countries:** Ecuador, Honduras
**Collaborators:** USDA-ARS, Zamarano (Honduras), FHIA (Honduras), Instituto Nacional autonomo de Investigaciones Agropecuairas (Ecuador), International Plant Diagnostic Laboratories Global Theme, Impact Assessment Global Theme, Information Technology and Databases Global Theme

## Research Achievements

**Development of an early test to evaluate cocoa resistance to witches´ broom**

Bioassays were conducted to establish factors that influence the plant response to *Moniliophthora perniciosa* inoculation on cocoa seedlings. The Holliday test, agar drop, and the belt spray methodwere compared as an early test for cocoa resistance against the witches´ broom pathogen. Five cocoa clones, SCA 6 and 12 resistant, EET 95 susceptible, and Gu 175 and CCN 51 with field tolerance, were used for assays of different concentrations of the pathogen *M. perniciosa.* Disease incidence and incubation period were used to measure responses.

Seedlings showed high levels of incidence of the disease with the modified Holliday test even with 25,000 spores per milliliter, which means that differences in resistance do not show. Using the other two methods, a clear tendency of the resistant SCA clones to present lower incidence values was found, especially with the two lower spore concentrations. The protocol to produce vegetative plantlets through cuttings from plants obtained through somatic embryogenesis has been developed and a series of 20 national clones with desirable agronomic traits are being reproduced to be evaluated for witches´broom resistance.

In the biological control of witches' broom, one of the bacterial treatments completely suppressed disease throughout the duration of the dry season and produced statistically significant disease suppression throughout the rainy season. These results support year-long disease suppression of witches' broom with simply three applications (at onset of dry season, onset of rainy season, and mid-rainy season) of the biological control agents and pruning of infected material just twice a year at the onset of each new season.

Additional research was conducted in collaboration with USDA's Sustainable Perennial Crop Lab (SPCL) to determine the modes of action of the bacterial endophyte in suppressing disease. The ability of the bacterial endophytes to activate plant defense mechanisms using Q-PCR techniques was investigated.

**Characterization of natural mixed cocoa plantain systems**

Cocoa-plantain farms from three localities, Virginia/Quevedo on the coastal plain, ~90 meters above sea level (masl); Guarumal/Mocache, low Andean hills, ±120masl; and San José de Tambo, Bolívar province part of the Chimbo watershed, ±500masl were monitored. Substantial differences in severity between the systems were found that may be due to weather conditions, especially the lower temperatures in Guarumal and Tambo as exemplified in Figure 1.

As a common factor, the three farms have an uneven distribution of plants with cocoa (the main crop) forming the most regular pattern, and plantain, fruits, and timber trees randomly growing between cocoa. Plantain forms irregular groups since farmers tend to plant it to cover areas where cocoa plants are missing, while trees, in general, grow naturally wherever a seed arrives.

So far, 33different symptoms have been observed and described from 26 causal agents (14fungus, one bacterial, five insects, four epiphytes and two possible abiotic problems). *Moniliophthor*a spp. (witches' broom and moniliasis) was the predominant one in all localities/seasons evaluated. The symptoms were expressed in several parts of the cocoa/plantain plants. Most of these symptoms were observed during the rainy season, a period where climactic conditions favor the development of phytosanitary problems.

In plantain, *Mycosphaerella fijensis* (Black Sigatoka) and *Erwinia* (Bacterial wilt) were found more than other fungal problems, with *Colletotrichum* (leaf spot), *Cordana* (*Cordana* spot), and *Deigthoniella spp* being present in all plots and both seasons. In general, as observed for cocoa, Virginia´s locality presented larger quantities of phytosanitary problems compared with Tambo and Guarumal (Figure 2).

Figure 1. Type and intensity of cocoa pathogens observed in three localities and two seasons from cocoa-plantain cropping systems in Ecuador. Pichilingue, 2008.

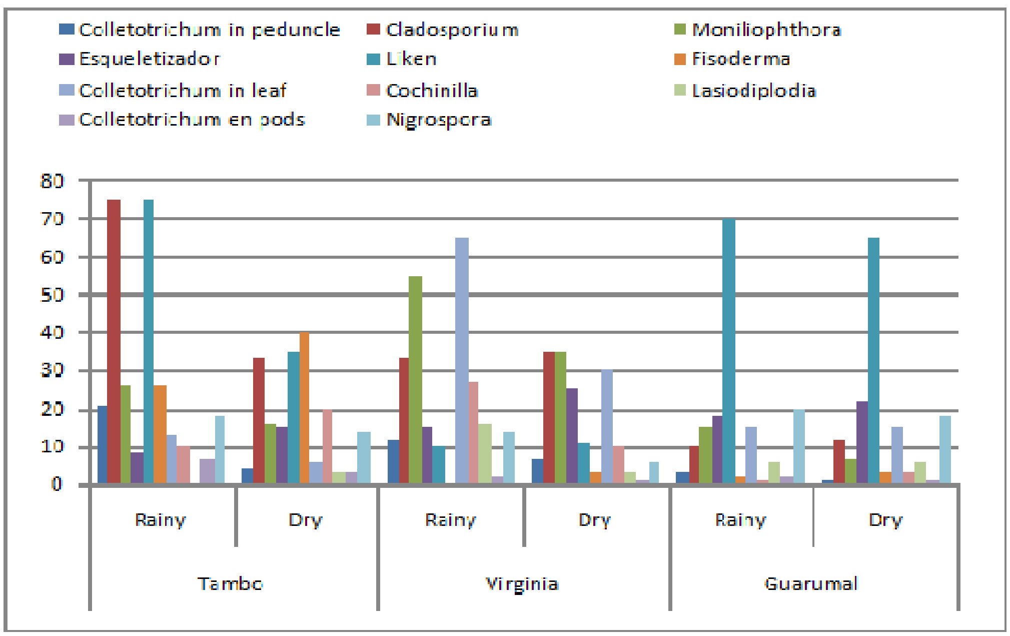
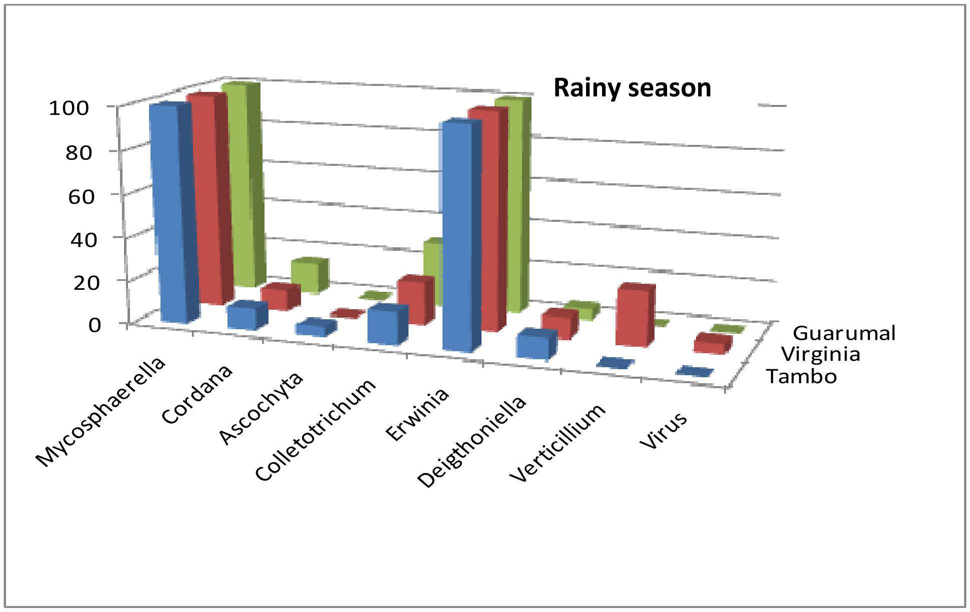
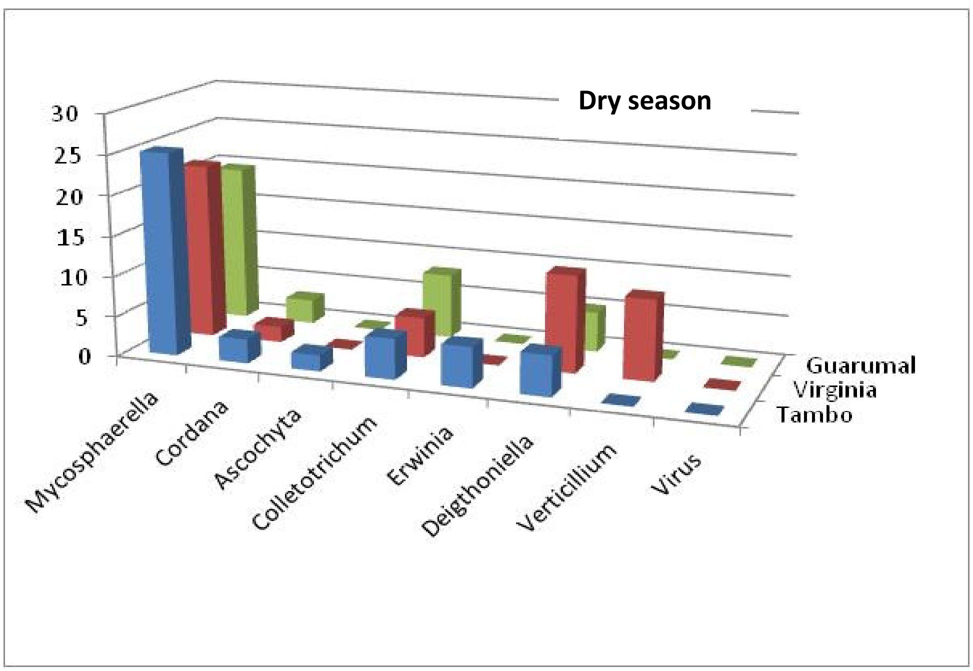


Figure 2. Type and intensity of plantain pathogens observed in three localities and two seasons from cocoa/plantain cropping systems in Ecuador. Pichilingue, 2008.



**Characterization of newly established mixed cocoa plantain**

Phytosanitary build up of a newly established, mixed system (cocoa plantain under different spatial arrangements).

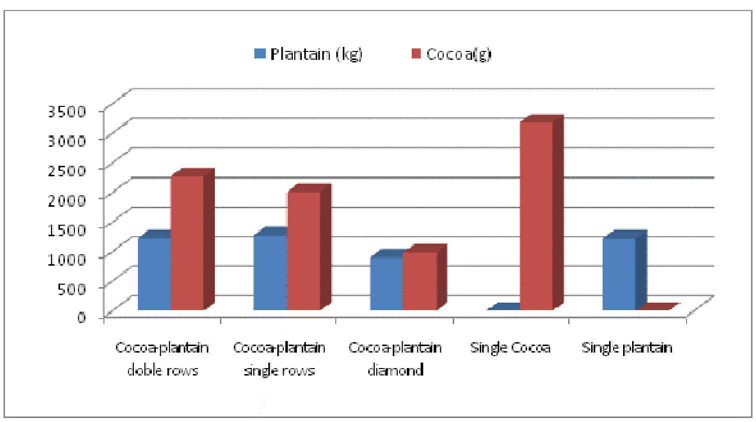
- Single cocoa and plantain plots registered the largest amount of luxes (16,000), followed by cocoa-plantain simple alternated rows, single plantain, double row system and diamond design being the lowest (9,500 luxes). A similar pattern was found for temperature within the plots, although differences were in the order of one degree Celsius or lower. Correspondingly, single crop systems presente the highest amount of infected material (shoots as brooms and cankers and pods), although some differences were noticed.
- Plantain continues to be a good barrier for cocoa disease spread, but the distribution of plants in the field also affects the spread of plantain diseases (i.e. Black Sigatoka), with all plots producing a disease index significantly different and lower than the single crop.
- The same factors that affect diseases also affect yield. The best plot for diseases – the diamond design – presented the lowest yield for cocoa. In plantain, differences were not as conspicuous as noted in Figure 3.

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

The rational use of fungicides is a good alternative to control naranjilla pathogens, however, it was found that increasing plant resistance can be more economical, practical, and ecologically friendly. As a result, emphasis was given on resistant segregating populations derived from F2 plants of five crosses between *Solanum quitoense* (naranjilla) with *Solanum felinum, Solanum vestisimun,* and *Solanum hyporhodium* to select for resistance to *Fusarium oxysporum* and *Phytophthora infestans*. All varieties of *S. quitoense* used in these crosses were susceptible to the pathogens, while all accessions of the other *Solanum* species used had some degree of resistance to both pathogens. This wide selection of parents, and the different types of resistance observed, provides a wide variation in sources of resistance to these pathogens, and is proving very useful in developing new varieties of naranjilla.

One hundred fifty F3 segregating plants from five crosses between *S. quitoense* with *S. hyporhodium*, *S. vestissimum,* and *S. felinum* coming from Indiana State University were evaluated for resistance to *F. oxysporum* at the green house (Sta Catalina Experimental Station, INIAP; Quito).

Figure 3. Yield values in cocoa (g) and plantain (kg) in different cropping designs during second year of trial. Pichilingue, September, 2008.



Two hundred twenty plants resistant to *F. oxysporum* were transplanted to a field in the Tandapi province of Pichincha to evaluate resistance to *P. infestans* during an eight month epidemic period. The local variety, "Nanegalito", was included as susceptible control. Resistance to *P. infestans* was evaluated using the following scale: 0 -- lesion absent; 1-- small almost, no perceptible lesions, 2 -- small to medium sized necrotic lesions regularly without sporulation, not causing stem break; 3 -- large soak lesions with abundant sporulation causing stem break. The number and size of the lesions were also evaluated for late blight. Using the late blight reaction types together with the number and size of the lesions, the segregating plants were classified as resistant (reaction type 0 and 1), intermediate (reaction type 2), and susceptible (reaction type 3). Incidence of anthracnose, another important disease caused by *Colletotrichum spp*., and fruit borer (*Neoleusinodes elegantalis*) incidence was included. At field level, relevant agronomical traits such as plant vigor, arming of the plant, fruit shape, fruit size, fruit quality, and yield potential were also evaluated.

Thirty-three segregating F3 plants with promising lines were selected from 1,250 plants initially evaluated for *F. oxysporum* f. sp. *quitoense* resistance. Late blight evaluation together with relevant agronomic traits was evaluated in these promising segregating plants. For late blight, the number of lesions, size of the lesion, and sporulation are highly correlated with infection types. Infection types are easy to evaluate and are closely correlated with the levels of resistance to *P. infestans*. Most of the segregating plants (19 out of the 33) did not show evident symptoms of late blight (reaction type 0). The rest of the plants showed reaction type 1 and 2, which represent intermediate resistance. This is promising compared with reaction type 3 of the local "common naranjilla" variety, which was so infected that yield fell to zero.

Five crosses presented similar rate of plants with resistance or intermediate reaction types. A major dominant gene appears to be involved in the resistance; however, the intermediate reaction types suggest that minor genes are also involved as few susceptible reactions were observed. Results of this study offer information for selecting efficient sources of late blight resistance, and also resistance material selected in these studies will help with the improvement of naranjilla through breeding programs.

**Epidemiological studies and control strategies of naranjilla anthracnose**

Since "common naranjilla" and the hybrids puyo and palora appear susceptible to *Colletotrichum spp*, chemical control together with adequate sanitation are the feasible strategies for anthracnose control.

Identification of the most efficient fungicides is a key step in developing IPM programs. Therefore, fungicides that were commercially available in Ecuador were assessed *in vitro* at the Sta. Catalina Experimental Station. Protective fungicides were evaluated at doses of 10,100 and 1,000 ppm, while systemic fungicides were evaluated at one, ten, and 100 ppm. This concentration was diluted on Potato Dextrose Agar (PDA) and distributed in 9cm petri dishes. A five mm plug of the fungus mycelium was then placed upside down in the center of the petri dish. A control without fungicides was also included in the experiment. Three replications of each dose were evaluated eight days after planting. For each dose, the percentage of mycelium growth in relation to the growth of the control treatment was calculated. Using growth percentage values, the EC´s were calculated using a regression analysis. EC50 is the concentration at which the fungus growth is restricted to 50%.

**Fruit borer control of naranjilla in Ecuador**

Naranjilla is a very important fruit in Ecuador. Recently, it has become an economic alternative for farmers on very critical soil and social conditions with increased demands from national and international markets for fresh naranjilla. One of the most important phytosanitary problems with naranjilla is the fruit borer (*Neoleucinodes elegantalis*). It can cause more than 80% of damage and as a result, farmers tend to apply high quantities of pesticides without technical parameters.

The efficiency of Abamectina applied alternatively with *Bacillus thuringiensis* using two types of sprayers and two spray frequencies was studied. Insecticide application was focused toward the inflorescence and in fruits smaller than 2cm.

The efficiency of *B. thuringiensis* and abamectina, as well as the localized application to inflorescences and early fruit stages, has been confirmed. New findings in this study include the efficiency of manual spraying under low application frequencies which, will provide important information in determining an efficient, easy, and ecologically-friendly way of controlling the naranjilla fruit borer. Use of the hand sprayer and low frequencies will reduce the amount of insecticide as well as the amount of water in the application, which will in turn reduce application costs. These techniques make applications easier and safer for farmers of the steep areas where naranjilla is grown.

### Evaluation of modern compounds and new application strategies to control fruit borer in naranjilla

The effect of four insecticides (Spinosad, Triflumuron, Imidacloprid, and Cyfluthrin) was examined on the fruit borer, *N. elegantalis* in naranjilla. Triflumuron applied every 15 days had the best quantity of harvested fruits 9.2 (range *a*). The other treatments, including the control, shared range *b* with values between 4.5 and 4.7 fruit per plant in average. The lowest damage percentage was shown by Imidacloprid (22%) and Triflumuron (22.7 %). Under these conditions, the control showed 88.7% damage (Table 1).

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

### Control of *Rhizoctonia* root rot of beets at La Esperanza, Intibucá

J. C. Melgar. FHIA.

*Rhizoctonia* root rot is a serious problem of beets in Honduras. An experiment was laid out as a factorial in a Randomized Complete Block Design with split plot arrangement, in which the main plots were a) soil solarization, b) application of the fungicide Banrot to the soil on the bed, and c) soil with no treatment. The subplots were treatments applied to the substrate used for plantlets production, either a) solarized, or b) not solarized. The vegetative growth and aerial plant parts' health and yield were superior in plots that received solarization than in plots that received chemical treatment and no treatment at all. The incidence and severity of Rhizoctonia root rot was much lower in plots with solarization than in plots treated with fungicide, which was similar to the control. Damage from white grub larvae to the roots was also lower in solarized plots as a result of mechanical interference of the plastic with the egg-laying female white grubs. No effect was observed on field performance of the crop as a result of solarization of the substrate used for plantlets production.

### Solarization of seedbeds used for production of tomato and pepper transplants

F.J. Díaz, FHIA.

The treatments were beds/substrate solarized for six weeks with either single or double layer transparent plastic (3 mil), in comparison to chemically-treated (Basamid®) and untreated beds/substrate. Solarization with a double layer of plastic made ground temperatures much higher than with a single layer. Crop seedlings from seedbeds with double plastic had lower mortality than from seedbeds solarized with a single layer or treated with Basamid®. Tomato and pepper plants grown on solarized seedbeds (either double or single layer) grew more vigorously, were consistently taller, and showed higher weight than those of the chemical treatments.

Table 1. The effect of low-toxicity insecticides on *N. elegantalis*. Tandapi, Pichincha 2008.

| Treatments | Yield* | | % of damage* |
|---|---|---|---|
| | plant | Hectare | |
| T1. Spinosad | 4.7 b | 7830.2 | 44.7 |
| T2. Imidacloprid | 4.5 b | 7497.0 | 22.0 |
| T3. Cyfluthrin | 4.7 b | 7830.2 | 63.8 |
| T4. Triflumuron | 9.2 a | 15327.2 | 22.5 |
| T5. Control | 4.5 b | 7497.0 | 88.7 |

**Solarization of cottage nursery substrate mixes used for screen house production of beet and lettuce transplants**

The treatments included beds or substrate solarized for six weeks with either single or double layer transparent plastic (3 mil), in comparison to two chemical fumigation options (Basamid® and Busan L®) and untreated seedbeds and substrate. Solarization with a double plastic layer led to ground temperatures much higher than with a single layer. Seedlings from seedbeds with double plastic had lower mortality than those from seedbeds solarized with a single layer or treated with Basamid® or Busan. No differences were observed in plant mortality between the treatments and the untreated control; however, beet and lettuce seedlings growing on substrate solarized with a double layer of plastic were taller compared to the other treatments. No clear differences were observed in biomass accumulation in beet and lettuce.

**Use of transplants produced in anti-insect screen houses as an IPM tool in production of crops of the Solanaceae, Cucurbitaceae, and Brassicaceae**
F. J. Díaz, Edilberto Rivera-FHIA.

In collaboration with RED-FINTRAC, a USAID-funded rural development project, a structure with the capacity for 100 planting trays was built in November 2007 at El Granadillo, San Petro de Tutule, La Paz. The production of seedlings under protected conditions increased the quality of the plants. Using the structure, 95% of plants survived and the loss was about 25% due to damping off, insect attack, and environmental conditions (wind and heavy rain) when grown outside.

**Evaluation of modified backpack sprayers for application of fungicides late blight pathogen of potatoes (*Phytophthora infestans*) in Honduras**
F. J. Diaz, J. Melgar, D. Perla and M. Rivera- FHIA.

An exploratory field trial was conducted from January to April to evaluate the performance of a man-held boom powered by a motorized knapsack and the addition of a constant pressure valve on lever-operated knapsacks. Although the incidence and severity of late blight was very low due to the dry season, there significant increases in produce yield occurred when application of the fungicides was carried out with a modified three-nozzle, single-row boom fitted to a standard motorized backpack sprayer, in comparison to the traditional single-nozzle, lever-operated backpack sprayers. Based on these promising results, a trial was designed for initiation in October coinciding with the most favorable time of the year for disease occurrence (high rainfall, high relative humidity. and low temperatures).

**Cowpea, *Vigna unguiculata*, as a rotation crop**

**Use of cowpea as a host for beneficial insects**
F. J. Díaz- FHIA.

Field assessment cowpea plants showed the presence of predators fromthe orders Coleoptera (coccinellids, chrysomelids, and carabids) and Hemiptera (Reduvids and Pentatomids), and parasitoids from the order Hymenoptera (Ichneumonidae, Braconidae, and Aphelinidae). The high production of foliage by the cowpea plants supported many beneficial insects.

**Use of *Dolichos lablab*, *Mucuna pruriens, Vigna sinensis* and *Sorghum* spp as rotation crops for the management of purple nutsedge *Cyperus rotundus* and root-knot nematode *Meloidogyne* sp.**
A. Rueda-Zamorano.

The cover crops were evaluated individually and combined with sorghum. The combination of *Dolichos lablab* and *Mucuna pruriens* was found to be the best treatment, reducing the purple nutsedge population by 15%. Results indicated that *Mucuna pruriens* reduced root-knot nematode population by 40%.

**Management of the white grub, *Phyllophaga obsoleta***

**Evaluation of entomopathogenic nematodes.**
The efficacy of the nematode *Heterorhabditis bacteriophora* in controlling larvae of *Phyllophaga obsoleta* was compared to a commercial insecticide (imidacloprid) by field application. No dead larvae attributed to nematode infection were observed.

**Studies on natural history of *Phyllophaga obsoleta*.**
Weekly collections of soil borne *P. obsoleta* adult females were collected and dissected to determine ovary and egg development. Adults were also trapped using a light trap. Females collected were dissected to determine ovary and egg development. The observations indicated that females that were attracted to the light trap had already laid most of their eggs.

**Evaluation of *Heterorhabditis bacteriophora* to control *Spodoptera frugiperda* in corn at Zamorano**
A. Rueda-Zamorano

In a study conducted to standardize the application method of the entomopathogenic nematode *H. bacteriophora* for the control of *Spodoptera frugiperda* in the field, lower nematode mortality was obtained at neutral pH using hollow cone nozzle at 30 psi. One hundred mesh filters limited the number of nematodes and increased mortality. Thirty- six hours after application, 100% nematode mortality was observed using 200 nematodes per 3rd instar *S. frugiperda* larvae.

**Evaluation of sticky traps for monitoring onion thrips, *Thrips tabaci***
There was a very low correlation between trap catches and direct counts. Observations of the previous year indicated a high correlation between trap catches and direct counts of the following week. The difference may be related to the date of planting, since the plot under observation in the previous year was planted early in the season when the thrips populations were starting to build up.

**Management of strawberry mite, *Phytonemus pallidus***
The treatment of strawberry planting material with hot water (43°C for 30 minutes) has been demonstrated to effectively kill all forms of *P. pallidus*.

**Management of *Thrips palmi* in Chinese eggplant; Effect of interplanting of sunflower**
A trial was conducted to determine the effect of inter-planting sunflower on natural enemies of the pest. Detectable populations of reduviid and geocorid bugs were observed on the sunflower, but not on eggplants.

**Management of the tomato fruit borer (*Neoleucinoides elegantalis*) in eggplant**
FHIA

The detection of fruit borer larvae in containers holding eggplant produced in Honduras at ports of entry in the U.S. resulted in destruction of the imported produce. As part of a comprehensive plan to manage this pest, field and packing house surveys were conducted in the Comayagua Valley, an area of concentration of eggplant crops for export to the U.S. market. Populations were undetectable in the field and infestation level detected in the fruit that reached the packing house was less than 1%. Two traps activated with *N. elegantalis* synthetic pheromone were deployed at FHIA's experimental station in Comayagua, but no moths were captured. Fruits of *Solanum torvum*, a common weed in the Comayagua Valley, have been found infested with a larva that seems to be *Neoleucinodes*. A factsheet on *N. elegantalis* was prepared, printed, and posted on the IPM CRSP website.

**Field determination of the reaction to frosty pod and black pod diseases of cocoa in promising cocoa germplasm using artificial inoculation**
Melgar-FHIA

Frosty pod rot (*Moniliophthora roreri*) and black pod (*Phytophthora* sp.) are the most important diseases of cacao in Honduras. A group of 22 genetic materials were evaluated for resistance to frosty pod rot, of which 12 were resistant. At the same tim,e 21 genetic materials were evaluated for reaction to black pod. Of these 21 materials, four were resistant. Three materials were resistant to both diseases.

**Evaluation of the antagonistic biopesticide fungus *Trichoderma* spp. for the control of *Fusarium spp*. in watermelon (*Citrulus lanatu)***
A. Rueda-Zamorano.

Four strains of *Trichoderma* sp. (Zamorano commercial strain, isolations from Choluteca and Costa Rica, and *Trichoderma koningii*) were tested for control *Fusarium* spp. in watermelon plants. Combinations of Zamorano + Choluteca had the highest antagonistic ability. Combinations of Zamorano+ Choluteca and Zamorano+ *T. koningii* showed a good *in vitro* interaction. Seedlings treated with the combinations showed a lower incidence of *Fusarium*, low mortality, and higher plant height.

**Evaluation of control alternatives for botrytis in blackberry and anthracnose in tree tomato in the Chillanes valley of Ecuador**
Blackberry (*Rubus glaucus*) and tree tomato (*Solanum betaceum*) are native species to Ecuador, and are widely cultivated in the internal valleys of the Andes. Both fruits have an important internal demand and they also have potential as exports. Many farmers of these internal valleys depend on these crops for food security and income; however, anthracnose of tree tomato (*Colletotricum spp*) and botrytis of blackberry (*Botrytis cinerea*) are the main constraints of the crops.

***Botrytis cinérea* in black berry**
*Botrytis cinerea* causes fruit rot in blackberry. Twenty-four commercially available fungicides were

tested in vitro using the agar plate dilution technique. The most effective protectant fungicides to inhibit *B. cinerea* mycelium to the tree isolates were captan and cupper hydroxide. Procloraz, cyproconazole, ciprodinil+ fludioxinil, himexazole, difeconazole, imazalil, and triadimefon were the most effective systemic fungicides to the tree isolates of *B cinerea* with $EC_{50}$´s lower than 10 ppm. The fungicides propioconazole, penconazole, pyrimetanil, and procymidone were less effective with $EC_{50}$´s ranging from 15 ppm to 50 ppm; and the systemic fungicides bupirimato and pent hydrate copper sulfate were considered not effective.

**Tree tomato anthracnose**

Isolates of *Colletotrichum spp.* have been recovered from leaves, senescent branches, and senescent peduncles after fruit harvest, and from fruits. Anthracnose symptoms caused by these isolates are being characterized.

On leaves, infections of *Colletotrichum spp.* are located on principal leaf veins and symptoms are long-sunken necrotic lesions. On senescent branches and peduncles, a descent necrosis is evident, especially in old trees. On fruits, round, sunken spots that grow rapidly, almost covering the entire fruit, are the main symptoms. An orange sporulation inside the fruit lesions is a distinctive characteristic of naranjilla anthracnose. Isolates causing these symptoms have been collected in Tumbaco-Pichincha and are being studied for pathogenicity at seedling and fruit stages.

The most effective fungicides to inhibit mycelium of *Colletotricun spp.* were azoxystrobin, difeconazole, hexaconazole, benomyl, bitertanol, and cyproconazole with EC50´s lower than 5 ppm.

**Development of cultural practices for pest management on mixed systems of cocoa/plantain using epidemiological and tech transfer tools**

Using a participatory diagnostic methodology, meetings with two groups of farmers were conducted within the study area with the aim of knowing farmers' perceptions of their problems and how to better characterize farming conditions in mixed cropping systems and the incidence/severity of phytosanitary problems as related to land slope, type of soil, weather conditions and general management.

There is a fair amount of corresponding knowledge of cocoa diseases and more is being built up with this and other projects, so there is an urgent need for a method to disseminate that knowledge among farmers. The curriculum for a series of transfer modules is in preparation. While the modules are being developed in a participatory manner, the curriculum will be reviewed and content will be added as needed. In addition to the participation of farmers from IPM CRSP activities, those involved in other projects (ACDI VOCA project in Ecuador) will be included in this activity.

Modules have been prepared showing the life/disease cycle of frosty pod rot and witches´ broom. The use of chemicals and IPM principles applied to cocoa orchards have been developed and tested. Resources from different related projects will be used to prepare a set of training modules, which will then be passed on to stakeholders.

Groups of students from two universities, Manta University, El Carmen extension, and the Technical University of Quevedo, have been working with farmer communities, and were trained on the use of these modules.

Information available with cocoa and plantain diseases is being digitalized in collaboration with the IT global theme program.

**Effect of the use of entomopathogens on the leaf litter and soil micro-fauna of plantain orchards in the coastal plain of Ecuador**

Communities of invertebrates present in the leaf litter of three cocoa/plantain systems (one plot of pure plantain from El Carmen region and a mixed crop- in San Joséde Tambo) were evaluated. Samples were taken once during the rainy season from three square meters each randomly chosen in the plantation. They were then transported to the laboratory in plastic bags where a "Berlese" and Winkler funnel traps collected all invertebrates present. These collections were kept in glass bottles with alcohol and labeled with locality and day of sampling for future more detailed identification. Levels of identification were chosen according the taxonomic resources available at Pichilingue: all invertebrates to "class"; insects to "order", and ants to "genus".

When the mixed San Jose de Tambo crop (~300masl) and pure plantain (El Carmen, 100masl) were compared, the former had roughly half the population of arthropods as the El Carmen (392 vs. 192 respectively). Class' insecta, acari, and collembola were the most frequent. Figure 5 shows the abundance of the community of insects present in the leaf litter of all the treatments of the Las Tecas Trial, where the mix crop treatments had the higher populations of insects, the single cocoa and plantain presented the lowest populations.

**Transfer of plantain and vegetable IPM programs from Ecuador and Central America to other areas of the Caribbean**

This transfer was facilitated through interactions at IPM CRSP annual meetings, by participation of Victor Barrera (Ecuador) in the impact workshop in Zamorano, Honduras, and by planning for the XI Mesoamerican IPM Congress held in Tegucigalpa, Honduras in October 2008.

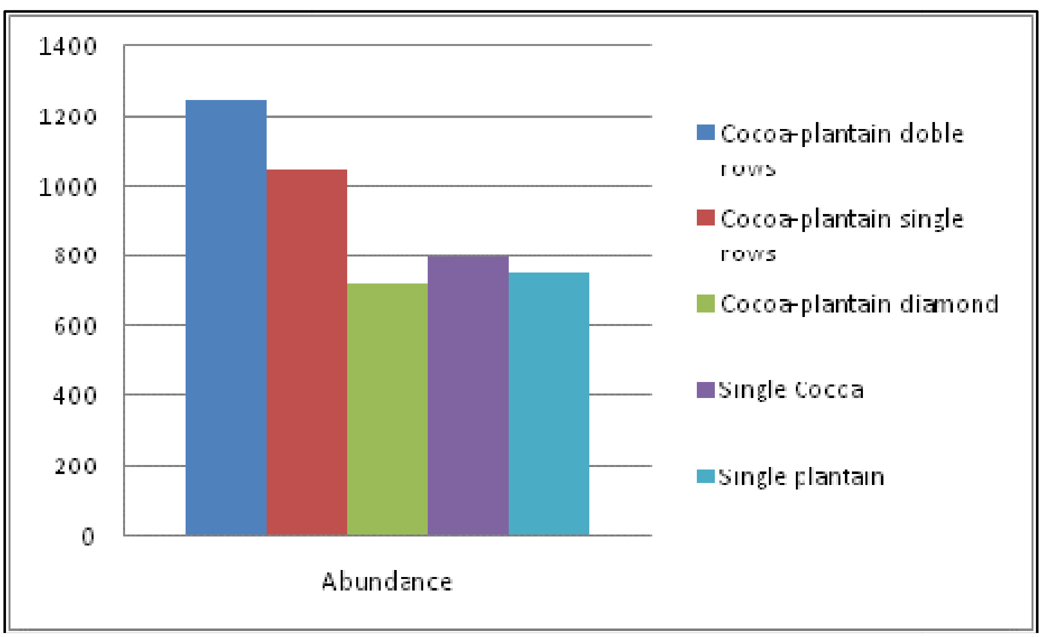
**Networking Activities**

Collaboration with the faculty of agronomy at the University of Cotopaxi-Latacunga, and the faculty of agricultural science at Central University–Quito and Technical University of Quevedo has been developed.

Cocoa/plantain participative studies have been conducted by contact with the farmers from "El recreo del Congo" (Buena Fe sector) and "El Paraiso" (La Unión sector) localities in the Los Rios and Cotopaxi provinces, respectively. These activities have been developed with the participation of unit (Nucleo) for technical support to farmers from INIAP and Los Rios Province authorities. The Tech Transfer Department from the Technical University of Quevedo was actively involved.

An agreement between INIAP and the NGO Randi-Randi was developed to disseminate the new IPM technologies on management of the fruit borer, nematodes, and diseases of naranjilla. Another agreement has been reached with Fundación CODEAMA, whose aim is to preserve and develop the Ecuadorian rainforest. IPM technologies in naranjilla are being spread in the Pastaza province through this agreement.

Figure 5. Average abundance (4 replications) of the community of insects presents in the leaf litter of all the treatments of Las Tecas Trial, rainy season, 2008.



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

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**Collaborators:** Makerere University, Uganda; Kenya Agricultural Research Institute; Sokoine University of Agriculture, Tanzania; National Agricultural Research Organization and Coffee Research Institute, Ugnda; Tanzania Coffee Research Institute; Thrips-Transmitted Tospoviruses Global Theme; Impact Assessment Global Theme; International Plant Diagnostic Laboratories Global Theme

**Tomato: Uganda**
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**Evaluation and dissemination of IPM packages**
A modified farmer field school (FFS) was set up at Busukuma sub-county headquarters. Through this school, demonstration gardens were established for teaching and training purposes. The FFS sessions were held at regular intervals at which scientists provided technical training on tomato production practices and IPM. Second, each grower established similar gardens at her/his own home and implemented all activities going on at the FFS demonstration gardens. The growers established their tomato gardens within close proximity of major community roads where they attracted the attention of passers-by. Finally, participating growers were registered for a competition where the evaluation criteria were set up by the growers themselves, with the three best growers receiving a prize. For the competition, each grower prepared and established four plots, each measuring 1.2m by 10m, and planted three IPM packages developed between 2005-2007 for control of priority pests and diseases of tomatoes (i.e. late blight, bacterial wilt, aphids, thrips, bollworms, and whiteflies) and a control. The components of the IPM packages included bacterial wilt resistant tomato variety MT 56, mulching, staking, and reduced pesticide use (1 spray of DM-45 + Metalaxyl + Dimethoate / week) combined as follows: (1) IPM Package 1: MT 56, mulching, reduced pesticide use (2) IPM Package 2: MT 56, staking, reduced pesticide use and (3) IPM Package 3: MT 56, mulching, staking, reduced pesticide use. The control was the grower's method, which included the farmer preferred tomato variety subjected to his/her own production and management system, and a chemical spray regime consisting of two-threesprays/week). Growers then visited and evaluated each others tomato fields.

**Highlights**
Competitions between individual growers and villages enhanced dissemination and adoption of IPM practices as it gave growers the opportunity to see and learn from each others tomato fields.

Twenty (20) tomato growers (14M/6F) participated in the scaling-up of dissemination and adoption of IPM packages through the FFS during this season.

Each of the 20 participants managed to train one other person in tomato IPM practices, while one lady managed to attract a group of 20 women, which she has introduced to and trained in tomato IPM.

Many trainees have been particularly impressed by the BW resistant variety (MT 56), which they have found to be high-yielding and of excellent quality compared to other commercial tomato varieties.

**Grafting tomato onto various indigenous root stocks**
The main objective was to evaluate the field performance of tomatoes grafted onto indigenous solanaceaous rootstocks. An on-station field trial conducted at MUARIK consisted of six treatments: bacterial wilt susceptible tomato variety "Onyx"

grafted onto four bacterial wilt resistant solanaceous rootstocks; three of which were indigenous (*Solanum complycanthum* (Kitengotengo), *S. indicum* (Katunkuma), and *Solanum* spp (Katengotengo); one wild eggplant rootstock from AVDRC (EG 203), and two control treatments, one of bacterial wilt resistant tomato variety MT 56, and the other of tomato variety Onyx. The six treatments were planted in a randomized complete block design that was used with three replicates. All the treatments were staked and mulched. A fungicide Agrolactyl (80% DM45 and 20% metalaxtyl) and an insecticide Dimethoate (40%) were applied once every two weeks. Data was collected on insect pests and disease incidence, growth, and yield parameters from 10 plants per plot at weekly intervals for three months.

Preliminary observations indicate: 1) Onyx, the BW susceptible check was wiped out by the third week after transplanting; 2) There were no differences in insect pests and late blight incidence and severity among all the treatments (with the exception of Onyx); 3) Tomatoes grafted onto the indigenous rootstock *Solanum complycanthum* (Kitengotengo) and EG 203 seem to be more resistant to bacterial wilt compared to the resistant check MT 56; 4) All grafted tomatoes were shorter, smaller, and yielded less than MT 56.

### Impacts of gender on IPM activities in Uganda

J. Bonabana-Wabbi, B. Mugonola, S. Kyamanywa, R. Namusisi, M. Waiganjo, R. Ssonko, Z. Muwanga, S. Musana M. Otim, D. Taylor, G. Norton, K.Montgomery, J. M Erbaugh.

Information on factors affecting adoption of IPM technologies by tomato producers has been collected in Busukuma sub-county. Results are being analyzed to form part of a B.S. student's special project report to be submitted to the faculty of agriculture within the Department of Agricultural Economics and Agribusiness at Makerere University. It was observed that most of the farmer field school participants were female (80%), and that among the various technologies promoted, improved seed variety (MT 56) was widely adopted, at least within the group. This was followed by reduced sprays, mulching (dry season), and staking during the rainy season, but adoption rates outside the group were relatively low. The high rates within the group could be attributed to group dynamics and social capital, which are important in reinforcing adoption decisions. A number of constraints hindered full-scale adoption of the technologies; especially limited availability of the improved MT 56, lack of staking materials and market accessibility, and the fact that in the market, it is quantity and not quality that determines who commands a bigger market share.

There are gender differences in adoption of IPM technologies in tomato production. Women are more keen on attending and participating in farmer field schools (FFS).

Factors like market accessibility, means of transport, resource ownership and control, marketing dynamics, and transaction costs explained the gender disparities in adoption rates. Nearly all farmers interviewed had adopted the improved variety MT56, and about 50% had used mulching, staking, and raising seed beds.

It was more profitable to grow tomatoes during the dry season, but lack of water for irrigation was prohibitive to farmers who did not own farms near swamps and water streams.

### Impact assessment of IPM efforts

Costs to disseminate and develop three tomato IPM technologies were obtained for Uganda. The three interventions were: a four-factor combination of mulching, minimum pesticides, raised seed beds and an improved variety of MT56; a four-factor combination of staking, minimum pesticides, raised seed beds, and MT56; and a five-factor combination of staking, mulching, minimum pesticides, raised seed beds, and MT56.

Overall, the cost to develop and disseminate the five-factor combination, which combined staking, mulching, raising seed beds, planting a resistant variety, and minimizing pesticide application was highest (Fig. 1). The expected benefits from this five-factor combination were also highest.

The combination involving mulching had the least cost due to the ease in accessing the mulching material, but it also had the least expected benefits due to the vulnerability of the tomato crop to pests in non-staked plots.

Women were 40% more likely to adopt IPM technologies than males because IPM practices are perceived to be both labor and time consuming and males are less likely to 'invest in such demanding activities.' Maximum adoption is expected in 2014.

Generally, costs for developing and disseminating IPM technologies have increased over the years.

Estimates of yield increments for dry season tomatoes ranged from 25% to 40% with IPM interventions.

**Country: Kenya**

**Pest management options on insect and disease incidence and their economic benefits.**

M.M. Waiganjo, M.N. Wabule, I. Onyango, B.M. Ngare, S. Kuria, S.B. Wepukhulu, M. Erbaugh, J. Kovach, S. Kyamanywa.

Trials were conducted on-station at KARI-Thika to test nursery protection using insect proof screen houses and need based application of bio-pesticides. Reportedly, four wilt-tolerant tomato varieties developed at KARI-Thika (TKA 81-1, TKA 193-31, TKA 155-18, TKA 193-2) were compared with a commercial variety, Cal. J, at the sub-plots, and three pest management options as the main plots.

**The three treatments included**:

1. IPM practice-pest scouting and need based pesticide application of bio-pesticides; namely, B.t, Dipel® alternated with neem, Nimbecidine®.
2. Farmer practice involving weekly application of fungicide (Mancozeb®) and fortnightly insecticide application; Dimethoate alternated with Deltamethrin (Decis®).
3. An untreated control with no insecticide application.

Disease incidence (bacterial and viral) was not recorded on any of the test lines or the commercial variety Cal. J. Arthropod pests observed included aphids, *Aphis gossypii*; leaf miners, *Liriomyza spp*.; red spider mite, *Tetranychus spp*.; thrips, *Frankliniella occidentalis*; and whitefly, *Bemisia tabaci*. There was no significant difference in pest population among the five tomato lines. However, significant difference in whitefly population (P=0.0015) was recorded among the pest management options. Tomato plants in the IPM option recorded significantly less whitefly numbers (1.42±0.15) than the farmer practice (2.17±0.17), which had the highest whitefly infestation, but not significantly higher than the untreated control (1.92±0.15).

The IPM practice with need-based pest control using biopesticides had the highest mean marketable yield (3,137.20kg/ha and 2,988.12kg/ha respectively), while the untreated control had the lowest mean marketable yield (1,667.23kg/ha). The highest economic benefits were recorded from the IPM practice, while the farmer practice incurred the highest costs attributed to routine pesticide use.

Figure 1: Cost schedules for three tomato IPM interventions: staking, mulching, and staking-mulching combined.

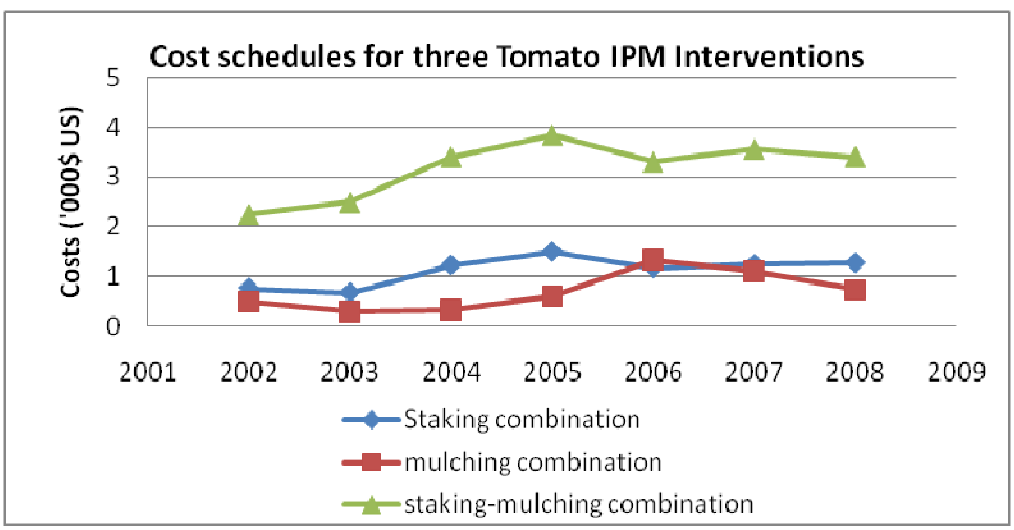
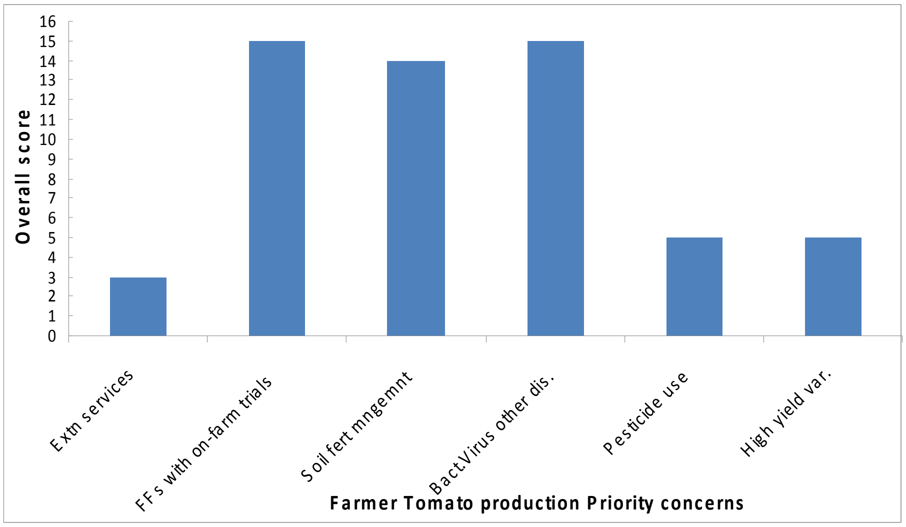


Figure 2: Mwea farmers' prioritization of tomato production concerns




**Evaluation of tomato lines against tomato pests and diseases at KARI-Mwea**

B.M. Ngari, M. W. Wabule, M. M.Waiganjo, S.B. Wepukhulu and Kariuki J. K.

Resistance evaluation of tomato lines against the major tomato diseases in Kenya was carried out on-station at KARI-Mwea field. Clear polythene sheeting was placed on the nursery bed for solarization. The seedlings were covered with muslin cloth after germination to protect them from early insect pest infestation and then transplanted after one month.

Fifteen tomato varieties were evaluated against arthropod pests and plant diseases during the period of November 2007 through March 2008.

The 15 cultivars were Tomato F1 Kago, Tomato F1 Tyrex, Tomato F1 Terminator, Tomato F1 Tyqueen, Tomato F1 Tyking, Tomato F1 Tropic, Tomato F1 7-09, TKA 155- 18, TKA 193- 31, TKA 193- 2, TKA 155- 28, TKA 81- 1 and three commercial varieties (Rio Grande, Onyx, and Valoria F1 Hybrid).

The major pests of tomatoes were early blight, *Alternalia solani*; bacterial wilt, *Ralstonia solanacearum*, tomato yellow leaf curl virus (TYLCV), and nematodes, *Meloidogyne spp*. Early blight significantly (P<0.05) varied with variety. Tomato F1 Tropic was not affected by early blight, while TKA 155-28 was significantly (P<0.05) infected. Other varieties were moderately infected.

The major arthropod pests observed included whiteflies, *Bemisia tabaci*; mites *Tetranychus spp*.; and leaf miners, *Liriomyza trifolii.* The population of mites varied significantly (P<0.05) with tomato varieties. Tomato F1 Tyrex and TKA193-2 had the lowest mean number of mites, while TKA 193-31 had the highest mean number of mites. Other varieties had moderate infestation. The population of other pests was not affected by variety.

The incidence of bacterial wilt ranged from 0-13%. The varieties differed significantly (P<0.05) on their height. Tomato F1 Kago, Tomato F1 Tyrex, F1 Terminator, and Tomato F1 Tyqueen were the tallest, ranging from 92-126cm, while varieties TKA 193-31, TKA 193-2, TKA 155-28, TKA 81-1, and Rio Grande were significantly (P<0.05) shorter. The infection levels of plant parasitic nematodes varied with varieties. Tomato F1 7-09, TKA 155-18, and Valoria F1 hybrid had the lowest mean number of galls with 2.22, 2.67, and 3.67 scores respectively. The infection by tomato yellow leaf curl virus (TYLCV) varied with the variety. Tomato variety Rio Grande had significantly higher infection rates of TYLCV disease than all others.

Yield and quality differed significantly (P<0.05) among the varieties. Tomato F1 7-09 had a significantly (P<0.05) higher percent of marketable fruits compared to all varieties. The lowest yields were varieties TKA 155-18 and TKA 193-31, which ranged between 9-11 tons/ha, while the highest yield (32 ton/ha) was recorded from tomato variety F17-09, surpassing the conventional commercial variety yields (12-23 tons/ha).

**Introduction of tolerant/resistant varieties for evaluation against Begomoviruses**

B.M. Ngari; M. M.Waiganjo, S. Kuria; S.B. Wepukhulu and Kariuki J. K.

Three lines received from the U.S. (D. Maxwell) are being tested against Begomoviruses on-station at KARI-Mwea using the standard protocol for virus testing. The new varieties include var Lianera F1, Romeli F1, and San Miguel F1 hybrids. Trial completion is expected by end of November 2008.

**Screened-beds for production of disease free tomato transplants.**

M. Ngari; M. M. Waiganjo, S. Kuria; S.B. Wepukhulu and Kariuki J. K.

A screen house constructed at KARI-Mwea had tomato seedlings planted inside the insect proof netting in mid-October 2008. Tomato seedling from the netting will be transplanted after one month and compared with non-protected seedlings in TYLCV and whitefly incidence.

**Pesticide usage fact finding meeting with Mwea Farmers**

Problems listed by farmers showed that most farmers (60%) prioritized tomato yellow leaf curl virus *"Kathuri"* as the most important production constraint, followed by bacterial wilt and blights (early and late). Among the important arthropod pests were mites, *Tetranychus spp*.; bollworm, *Helicoverpa armigera*; whiteflies, *Bemisia tabaci*; aphids, *Aphis gossypii*; and thrips, *Frankliniella occidentalis.* Other constraints listed were soil infertility and high pesticide prices**.** The Mwea farmers claimed that they had not been trained on tomato IPM, but they had learned from each other or asked agro-chemical dealers advice on chemicals to be purchased.

Farmers' interventions/control measures for "*Kathuri"* disease included doing nothing, uprooting, rotating crops, controlling whiteflies, or applying insecticides. Most of the farmers (70%) managed bacterial wilt ("*Kuthingitha*") by uprooting and burning the infected plants, using crop rotations with onion and tomato at the nursery level, or applying Achook® and Mocap®. Other farmers mentioned blocking furrow irrigation water away from diseased plants, applying concoctions or use of a tolerant variety, and "*Valoria F1 Hybrid*." Management of late blight disease ("Barafu") and arthropod pests was done solely through the use of chemical pesticides.

**Mwea farmers' training at KARI-Thika 1**

Seventeen presentations were made. Farmers were equipped with knowledge on pesticide use, pest and disease identification, nursery preparation and management, record keeping, post harvest handling, and value addition of the tomato crop. A pre- and post-test evaluation was administered to the participants to assess the training impact. Farmer pre-evaluation and post-evaluation scores (Figure 1) showed improvement in farmer knowledge in the good and excellent categories, while the category of average and failures decreased after training from 13.8% to 4.2% and 27.6%to 33.3% respectively.

The farmers listed their primary tomato production concerns that needed to be addressed (Figure 2). The issues listed included farmer field schools; management of bacterial, viral, and other diseases; soil fertility management; more training on safe use of pesticides, high yielding varieties, and extension services in that order of importance.

**Womens' role in tomato production and pest management in Mwea, Kenya, and Morogoro, Tanzania**

Wairimu Mwangi, Maria Elisa Christie, and Mark Erbaugh.

The objective was to examine the influence of gender on tomato production, including pest management at East Africa Regional IPM CRSP research sites in Mwea, Kenya and Morogoro, Tanzania. Baseline surveys conducted at both sites were used as the data source for this analysis. At the Mwea site, 120 tomato farmers (100 males and 20 females) were interviewed. At the Morogoro site, 100 farmers (67 males and 33 females) were interviewed.

In general, farmers at the Morogoro site are more likely to use extension officers as their first source of information. Female farmers at Morogoro were more likely use extension officers as their first source of information. At Mwea, none of the female farmers reported using extension officers as the first source of information.

This may suggest that access to extension was more likely at Morogoro for both male and female farmers. At Mwea, female farmers have limited access to extension. At both sites, the most common form of pest management was use of pesticides. All the farmers interviewed at both sites reported using pesticides for pest management.

In general, farmers at Mwea were more likely to observe pesticide use safety procedures than farmers at Morogoro. Within their respective sites, female farmers were just as likely as male farmers to observe pesticide safety procedures.

Knapsack sprayer ownership:

- At Mwea, male farmers as likely as female farmers
- At Morogoro, male farmers more likely than female farmers
- In general, farmers at Mwea were more likely than farmers at Morogoro

Inorganic fertilizers were a common production input at both sites. There were no gender differences in fertilizer use.

Farmers at Mwea were more likely to use farmyard manure for tomato production (very slight gender differences). Only one male farmer reported using farmyard manure for tomato production.

At Mwea, stakes and ties were commonly used in tomato production. While males were more likely to report using stakes and ties, the gender differences were very modest.

Farmers at Mwea were more likely to report that they had received IPM training as well as training on insect identification, pesticide usage and pesticide safety than farmers at Morogoro. Actually at Morogoro, none of the farmers had received IPM training, and only one farmer had received training on insectidentification, pesticide usage, and pesticide safety.

**Country: Tanzania**

**Tomato field trail**

The treatments consisted of using two tomato varieties (CAL-J and Tanya). The trial then used fertilizer application, mulching, IPM, intercropping with cabbage, standard farmer practice, intercropping with spider plant, and no control measure.

Variety CAL-J gave higher marketable yields compared to Tanya; however, Tanya produced bigger fruits. For both varieties, mulching was superior overall for yield and intercropping had no advantage (Table 1). Both varieties were infested with leaf miners (*Liriomyza* spp.) at an incidence level averaging 25% with no differences between management practices. Disease incidence was generally low, while bacterial leaf spot (*Xanthomonas campestris pv. vesicatoria*) was the most prevalent with a mean score of 1.1 on a scale of 1-5.

**Establishment of demonstration plots of IPM practices**

Based on farmer evaluation of on-station trials, three treatments were selected for on-farm demonstration: (1) Current farmer practice = cultivation + weeding twice + fertilizer (top dressing only) + routine insecticide & fungicide application; (2) IPM.1 = cultivation + mulch + supplementary weeding (when needed) + insecticides & fungicides as needed; and (3) IPM.2 = herbicide + fertilizer (basal + top dressing) + supplementary weeding (when needed) + insecticides & fungicides as needed. These practices were demonstrated using two varieties of tomato (Tanya and CAL-J) treated with 2% sodium hypochlorite (laundry bleach) left or untreated. The demonstration plots were established at Mlali and Manza villages. These plots were also used to train farmers on nursery establishment, field establishment and fertilizer application, and scouting for insects and diseases.

A total of 30 farmers (15 from each village) participated in the activity. On average, 22 farmers (7F/15M) attended the weekly sessions.

**Assessment of yield loss due to weeds in tomato**

Yield loss assessments due to weeds for tomato, sweet pepper (*Caspsicum annum*), eggplant (*Solanum melongina*), Chinese cabbage (*Brassica chinensis*), and Okra (*Abelmoschus esculentum*) were done in a field trial under weed-free and un-weeded conditions. Treatments were arranged in a split plot with vegetable types as main plots and weed management as sub plots, laid out in a randomized complete block design with three replications. Growth and yield variables of the vegetables, weed types, and weed dry biomass were recorded.

Weeds left unchecked assumed dominance soon after the vegetables were established (Figure 3.1). However, Chinese cabbage and tomato were relatively more competitive against weeds compared to sweet pepper and eggplant, which failed to produce harvestable yields under season-long weed competition (Figure 3.2). The most dominant weeds were blackjack (*Bidens pilosa*), wondering jew (*Commelina benghalensis*), Mexican fireplant (*Euphorbia heretophylla*), and *Digera muricata.*

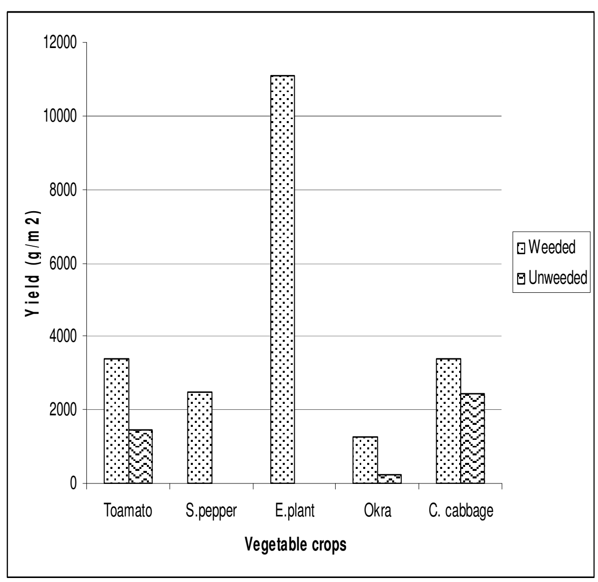
Table 1: Tomato yield under different management practices

| **Management practices** | **Varieties** | | | |
|---|---|---|---|---|
| | **Tanya** | | **CAL-J** | |
| | No. fruits $m^{-1}$ | Marketable yield (kg $m^{-1}$) | No. fruits $m^{-1}$ | Marketable yield (kg $m^{-1}$) |
| Fertilizer | 88 | 5.1 | 132 | 6.2 |
| Mulching | 85 | 6.8 | 168 | 9.2 |
| IPM | 60 | 3.5 | 118 | 6.4 |
| Intercropping with cabbage | 74 | 4.5 | 118 | 5.5 |
| Farmers' current practice | 91 | 5.6 | 144 | 7.4 |
| Intercropping with spider plant | 78 | 4.8 | 97 | 4.4 |
| Control | 27 | 1.9 | 26 | 1.1 |

CV (%) for no. fruits = 38.2 and 34.8 for marketable yields.

Figure 3.1 Weed competition in vegetable crops: Crops smothered by weeds and weeded (right)

Figure 3.2. Effect of weeds on yield of various vegetable crops



## AVRDC

### Spider plant (*Cleome gynandra*) as repellent crops for *Thrips* sp in tomato

Marcella Dionisio, Drissa Silué, Greg Luther

The objective wass to determine the efficiency of *Cleome ginandara* repellent crop for *Thrips* sp. The experiment was conducted at AVRDC-RCA in Arusha. Tengeru 97 was the tomato variety used. Three treatments, tomato monoculture, tomato intercropped with spider plant, and spider plant monoculture, were compared in a randomized complete block design experiment with three replications. Hand-made traps (50 x 35cm) using polyethylene white plastic sheets were made and spread with trapping insect glue OEKOTAK® (Oecos LTD, UK) for the first season and STIKEM® (Seabright Laboratories, USA) for the second season. Five of them were put in each treatment and replaced every week with new ones.

Spider plant as a repellent crop did not affect the presence of *Thrips sp* on the tomato.

### Tanzanian sunhemp (*Crotalaria ochroleuca*) as repellent for thrips in tomato

The experiment was conducted at AVRDC-RCA in Arusha. Tengeru 97 was thetest tomato variety. The crops were raised using standard cultural practices. Three treatments, tomato monoculture, tomato intercropped with Tanzanian sunhemp, and Tanzanian sunhemp monoculture, were compared in a randomized complete block design experiment with three replications. Hand-made traps (50 x 35cm) using polyethylene white plastic sheets wereade and spead with with trapping insect glue OEKOTAK® (Oecos LTD, UK) for the first season and STIKEM® (Seabright Laboratories, USA) for the second season. Five traps were put in each treatment and replaced every week with new ones.

There were significant differences among the three treatments in 2007. The tomato monoculture recorded the highest number of thrips, while it was lowest in Tanzanian sunhemp monoculture. The reduction in the number of thrips in all treatments during 2007 wass due to heavy rains combined with low temperatures that occurred during the fifth week. The effect of the Tanzanian sunhemp as a repellent crop clearly affected the presence of *Thrips sp* on tomato. However, the results could not be confirmed in the 2008 trial, as no significant differences between the three treatments were found. The tomato fruit yield indicated that there was no negative effect of intercropping with Tanzanian sunhemp.

### Screening tomato lines against red spider mites (RSM)

The experiment was conducted at AVRDC-RCA in Arusha. Eleven accessions (ARP365-1-4, ARP365-2, ARP365-2-5, ARP365-3-25, ARP366-1, ARP366-2, ARP366-3, ARP366-4-2, ARP366-4-23, ARP367-1, Tengeru 97) originating from the AVRDC gene bank were raised in the nursery for six weeks and then transplanted at a spacing of 60cm between rows and 40cm between plants. The plants were evaluated every week for the presence of RSM using a 0-5 scale.

Results obtained after 11 weeks for RSM assessment found that ARP366-3, ARP366-4-23, ARP366-4-2, ARP365-3-25, ARP365-1-4, and ARP365-2-5 showed the lowest susceptibility, while ARP367-1 was the most susceptible one. ARP365-1-4, ARP365-2-5, and ARP366-4-2 showed a delay in the infestation with RSM, which may be due to their tolerance to this pest. These lines were followed by ARP366-3 and ARP366-4-23. The yield was higher when a line was less affected by RSM (e.g. ARP366-4-23, ARP365-1-4, ARP365-2-5).

The RSM samples sent to ICIPE for identification indicated that *Tetranychus evansi* was the RSM present in our field.

During the second season of this experiment, RSM attack did not occur in the field, probably due to high humidity and low temperatures.

### Biocontrol of soilborne diseases using Brassica crops

Broccoli (var. Calabrese) and African indigenous crops [Ethiopian mustard (Mbeya green and Mbeya purple) and spider plant (green and purple stem)] were tested for their bio-fumigation properties against soilborne diseases. On the other hand, four susceptible crops such as tomato (Tengeru 97), hot pepper (var. Long red cayenne), African nightshade (line SS52), and African eggplant (variety UVPP) were evaluated as soiborne susceptible crops on bio-fumigated plots. The bio-fumigant crops were allowed to grow for six weeks. After that they were ploughed under and integrated in the soil as a green manure for two weeks with high irrigation to permit glucosinolate degradation. The test crops were transplanted and the number of dead plants recorded weekly. Roots of dead plants were sampled and taken to the laboratory for disease identification.

Figure 4. Tomatoes infected with a tospovirus from farmers' markets in Uganda showing chlorotic spots, blotches, and rings.


Results obtained showed significant differences among the treatments tested. Hot pepper and tomato plants were more susceptible to soilborne diseases. On the contrary, African nightshade and African eggplant had no or very few dead plants.

Because tomato and hot pepper were the most susceptible Solanaceae crops to soilborne disease, the focus was on the results for these crops. In tomato, the treatments with less dead plants were the green stem spider plant for the first season and the purple stem one for the second season. Then, the treatments with more dead plants were the untreated control for the first season and Mbeya purple for the second season.

**Integrated management of thrips-borne tospoviruses in vegetable cropping systems**

**Documentation of viruses in vegetables.**
Naidu Rayapati and M. K. N. Ochwo-Ssemakula

**Uganda:**
A survey of four major vegetable markets in the Kampala district of Uganda was conducted for the presence of tospoviruses in tomatoes. Several tomatoes in these markets showed various types of chlorotic rings and blotches indicative of tospovirus infection. A preliminary testing of these fruits using immunostrips from Agdia (Agdia Inc, Elkhart, IN) revealed the presence of *tomato spotted wilt virus* and *impatiens necrotic spot virus*.

**Hot Pepper**

**Country: Uganda**
J. Karungi, S. Kyamanywa, G. Tusiime, M. Ochwo, P. Agamile, G. Luther, S. Miller and J. Kovach

**Development of integrated pest management (IPM) options to improve quality and increase quantity of hot pepper exports**

**Viral disease characterization and role of farm-generated seed in transmission of hot pepper diseases**
ELISA results on seed samples indicated the presence of *Chili veinal mottle virus* (ChiVMV), *Cucumber mosaic virus* (CMV), *Pepper mild mottle virus* (PMMV), *Pepper veinal mottle virus* (PVMV), *Tobacco mosaic virus* (TMV) and *Tomato mosaic virus* (ToMV). TMV was the most prevalent virus in the farmers' fields surveyed, followed by PMMV, PVMV, ToMV, and CMV. ChiVMV was the least commonly detected. In leaf samples from seedlings raised from farmers' seeds, only PVMV and PMMV were detected, indicating that they are seed-transmitted.

**Assessment of eco-friendly pest management options including cover cropping, use of a biopesticide (neem), and prophylactic treatments with a pesticide**
A split plot randomized complete block design with three replications was used with the hot pepper + cowpea system vs. a hot pepper monocrop with four pesticide treatment options in

each main plot. The pesticide treatments were: i) prophylactic treatment of plots at transplanting with granular carbofuran; ii) weekly sprays of a neem based formulation; iii) combination of the prophylactic carbofuran treatment and neem; iv) weekly sprays with sulphur (added after finding that the broad mite was devastating hot pepper); and v) the untreated control.

Results indicated that the hot pepper + cowpea system greatly lowered infestations of aphids and nematodes on hot pepper, but not thrips; and brought about a yield penalty on hot pepper. Prophylactic applications of carbofuran and/or sprays of a neem formulation lowered populations of aphids and whiteflies on hot pepper and increased the yield of pepper.

**AVRDC**

**Marigold as a trap crop for thrips in hot and sweet pepper fields**

Marcella Dionisio, Drissa Silué, Greg Luther

Marigold as a trap crop was tested in a randomized block design with three replications. Maize was used as a barrier between the treatments. Four treatments [hot-pepper (var. long red cayenne) monoculture, hot-pepper with marigold along the borders, sweet pepper (var. yolo wonder) monoculture, and sweet pepper with marigold along the borders] were tested. Six white, sticky traps were prepared and erected in each plot. The traps were changed weekly and then the number of thrips was recorded on the removed traps in the lab using a stereo microscope.

The data indicated that the planting of marigold plants should be set away from pepper crops to attract thrips and to prevent them from establishing on the pepper crops. The marigold plot can then be sprayed with insecticides to reduce thrips incidence.

**Biologically-based interventions for managing the tomato fruitworm (*Helicoverpa armigera)***

**Country: Uganda**

S. Kyamanywa, M. Otim, Namulonge, A. Roberts, G .C. Luther, Zachary Muwanga

**Assessment of infestation and damage by *H. armigera* under different spray regimes**

There was no larval infestation in all insecticide treated plots on all sampling dates, whereas the numbers of larvae in unsprayed plots averaged between 0.03 to 1.4 larvae per plant.

**Assessment of the role of intercropping on the incidence and damage by *H. armigera***

In the intercropping experiment with tomato only (sprayed and unsprayed), and tomato intercropped with maize, sorghum, or beans, the mean numbers of larvae recorded per plant were: 0.04 (unsprayed), 0.03 (bean/tomato intercrop), 0.01 (maize/tomato and sorghum/tomato intercrop), and none in the insecticide sprayed plots.

**Passion fruit**

**Country: Uganda**

M. Ochwo-Ssemakula, J. Karungi and S. Kyamanywa, P. Seruwagi and M Otim, M Erbaugh, S. Miller and P. Redinbaugh

**Screening molecular primers for use as diagnostic tools in virus detection**

Five pairs of molecular primers developed at The Ohio State University in 2007 to detect the prevalent potyvirus infecting passion fruit in Uganda were used on a subset of virus isolates representing the agro-ecological zones covered by the districts sampled.

The predominant insects occurring on passion fruit were mites and ants. Aphids were rare during the sampling period; however, a single specimen of the *Aphis* sp. was recovered from the Wakiso district.

Primer reactions were optimized and will be used to characterize the collection of virus isolates in the year 2008-2009. RAPD analysis, using a cross section of local passion fruit types, indicated low levels of genetic diversity. Previously, these passion fruit types had been characterized in an on-station trial using morphological traits, with high levels of phenotypic variation being realized.

## Country: Kenya

Amata, R. L., Otipa, M. J., Waiganjo, M.M.; Kahinga, J.; Kuria, S.; Kinoti, J., Ndirangu, S., Langat, B.

### Survey of viruses and fungi affecting passion fruit in Kenya

To determine the distribution and incidence of passion fruit-infecting viruses, surveys were conducted in eight hotspot selected districts: Murang'a, Thika, Bungoma, Trans Nzoia, Nakuru, Molo, and Embu.

There was a presence of typical viral-like symptoms on passion fruit in all eight surveyed districts. These included vein clearing, leaf curl and roll, fruit hardening and deformation, foliar mosaics, spot and/or diffuse chlorosis, and crinkling. Incidence and severity of virus-like symptoms in the eight districts surveyed showed that Trans Nzoia had the highest incidence (78.4%) and severe virus symptoms (4), followed by the Thika district with 72.2% and severe virus symptoms (4), while samples from the Murang'a District showed the least incidence and severity symptoms (30.4%) and (2) respectively. Using antigen coated plate-ELISA, 32% of the samples tested (46) were positive to potyvirus antisera.

### Detection of viruses infecting passion fruit in Kenya

RNA extraction for 48 samples was done using the Qiagen Rneasy plant mini kit. First-strand cDNA synthesis using Thermoscript Reverse Transcriptase and using actin and rubisco primers was carried out on 12 samples to ascertain the presence of good quality RNA. After subsequent PCR amplification of the cDNA, the expected products were observed on 1% Agarose gel for all the samples, indicating that RNA was present for all the test samples.

**Indexing for CMV: Forty-eight** symptomatic and asymptomatic samples were collected from different divisions of Eastern provinces (Embu and Meru districts), and 12 passion fruit indexed for the presence of CMV using RT-PCR protocols. Primers specific to CMV 2 primers were used including CMV1/CMV2 and CMV3/5. For CMV1/CMV2, no bands were amplified for all the test samples.

Thirty-six (36) more PF dried leaf samples from Embu and Meru districts were indexed for CMV using primers specific to CMV (CMV1/2 and CMV3/5). Following PCR amplification of the cDNA, the expected products for CMV3/CMV5 were observed on 1% agarose gel for seven out of 36 samples tested. For CMV1/CMV2, 24 samples have been tested and four samples have tested positive, although the bands were not distinct for two samples.

### Survey of fungal diseases of passion fruit

Disease symptoms and fungi isolated included: leaf spots (*Alternaria passiflorae, Septoria passiflorae*), fruit spots (*Colletotrichum passiflorae, Alternaria passiflorae, Glomerella cingulata, Pestalotiopsis mangiferae*), Dieback (*Phytophthora nicotiana var. parasitica, Fusarium solani, F. semitectum, F. pseudoanthophilum, F. subglutinans, F. oxysporum*) and Wilt, (*Fusarium oxysporum*).

The four diseases affecting passion fruit were reported in all the provinces except for wilt disease, which was not reported in Kisii (Nyanza). Several *Fusarium* and *Phytophthora* species were isolated from diseased plants exhibiting symptoms. Die back disease had the highest incidence and severity. Some farmers, especially in Ithanga, Kisii, and Nakuru, had lost the entire crop (100% loss) due to this disease.

Fungal diseases observed were the same across the regions surveyed, with the exception of *Fusarium* wilt disease which was not reported in the Nyanza District. Dieback disease associated with *Phytophthora nicotiana* var. *parasitica.* and *Fusarium* spp. had the highest incidence and severity in all the provinces with records of 5-100 and 1-3 respectively.

*Fusarium* wilt disease had relatively lower incidence of 0-10. High incidence of dieback disease may be attributed to the lack of close monitoring and scouting of the disease by most of the affected farmers and limited resources for disease management.

The synergy of the two fungal species may aggravate the dieback disease in passion fruit growing areas, especially where the crop is not well fertilized.

The hotspot regions for dieback included Meru, Embu, Ithanga, Nakuru, and Molo. The climatic conditions and diverse cropping systems in the region may also have facilitated the survival and propagation of these pathogens.

Incidence of leaf and fruit spots caused by *Alternaria passiflorae*, *Septoria passiflorae, Colletotrichum passiflorae,* and *Glomerella cingulata* ranged between 5-85% across the provinces. Leaf spots caused by *Alternaria passiflorae* in passion fruits were isolated most frequently (52), followed by *C. passiflorae* (46), across the districts. Ithanga had a significantly higher leaf/fruit spot isolation ($\chi^2$ =35.973, d.f=20, p=0.015). The severity of the fungal diseases may have been aided by climatic conditions, which were conducive during the season.

In the Coast Province, *Septoria passiflorae* was the predominant pathogen associated with leaf and fruit spots, indicating a possible climatic influence.

**Screening *Passiflora* species for drought and *Fusarium* wilt tolerance**

Robert Gesimba and Dan Struve

Species of the subgenus *Passiflora* rooted in higher percentages than species of the *Decaloba* subgenus (81% vs. 64%). Cuttings of *Passiflora gerbertii* L., *Passiflora caerulea* L., and *Passiflora subpeltata* Ortega could be rooted in high percentages and were compatible rootstocks with the purple passion fruit. *Passiflora incarnata, P. caerulea,* and *P. subpeltata* had a higher drought tolerance than the other species.

*Passiflora edulis f. flavicarpa* and *P. suberosa* were resistant to *Fusarium* wilt. *Passiflora incarnata* and *P. mollisima* were moderately resistant to *Fusarium* wilt. Ecotypes of *Fusarium oxysporum* f. sp. *Passiflorae* isolated from diseased passion fruit plants from Uasin, Gishu, and Kericho were similar to each other, while inoculum from Molo and Nakuru were also similar to each other.

**The effect of irrigation, substrate type, and irrigation in the occurrence and suppression of *Fusarium* wilt**

Integrated container-irrigation system (ICIS) pot irrigated passion fruits had longer vines in the field. The use of ICIS pots and ICIS mulch, together with either rodozin or root-guard treatment is recommended because it gives short term *Fusarium* wilt suppression and increases vegetative growth.

There are two strains of *Fusarium oxysporum* f. sp *passiflorae* in Kenya. *Passiflora edulis f. flavicarpa* is resistant to *Fusarium* wilt.

The integrated use of ICIS pots and ICIS mulch, together with either and rodozin or root-guard treatment, is recommended because it reduces *Fusarium* wilt incidence by 91.67% and increases vegetative yield by 50%.

Table 2: Pests and agronomic constraints in passion fruit production in Tanzania

| | Pests | Species |
|---|---|---|
| 1. | Insects | Termites (*Microtermes thoracalis*)<br>Leaf hoppers (*Empoasca spp* )<br>Red spider mites (*Tetranychus urticae*)<br>Leaf miners (*Liriomyza* spp.)<br>Fruit flies (*Bactrocera* spp.)<br>Stinkbugs (*Nezara viridula)* |
| 2. | Diseases | (i) Fruit surface wrinkling and premature fruit drop |
| 3. | Weeds | (i) *Panicum* spp. – Guinea grass)<br>(ii) *Cyperus* spp – Nutgrass<br>(iii) *Cynodon dactylon* – Star grass<br>(iv) *Sida* spp – Broomweed<br>(v) *Conyza* spp – Fleabane |
| 4. | Agronomic constraints | Poor crop management practices (inappropriate spacing, trellising, pruning, and weed management)<br>Insect and disease control<br>Lack of irrigation and moisture conservation techniques<br>Narrow genetic base and unidentified varieties. |

**Country: Tanzania**

**Baseline information of major pests and diseases of yellow passion fruit**

Field surveys were conducted in the Morogoro district (five farms); Mvomero district (three farms) within the Morogoro region, Bagamoyo district (five farms), and Mkuranga district (five farms) in the coast region.

Important insect pests, diseases, and weeds observed in the surveyed farms are presented in Table 2. The table also shows the agronomic setbacks which constrain passion fruit productivity.

**Banana**

**Country: Uganda**

Tusiime Geoffrey, Sally Miller, Melanie Ivy, Kyamanywa Sam, Adikini Scovia

**Use of PCR to detect monitor progressive movement of *Xanthomonas campestris* pv. *musacearum* in apparently healthy banana suckers**

**The objective was to study the movement of *Xanthomonas campestris* pv. *musacearum* in infected banana using PCR**

*Xcm* migrates fairly quickly from the top to the bottom of the plant before any observable symptoms develop. By the time banana wilt symptoms are recognized*, Xcm* has moved from the top to the base of the plant and possibly into the suckers, although it remains latent. Therefore, such suckers pose danger as dissemination vehicles for the disease, and may be the reason for the continuous spread of the disease in the region.

It takes a long time between inoculation and seeing any symptoms (incubation period), which further increases the likelihood of using infected suckers as planting material unintentionally.

There is no genotype effect on the rate of movement of *Xcm* in banana. In all cultivars sampled for this study, bacteria were detected at the pseudostem bases and in their suckers.

It is recommend that plants exhibiting xanthomonas wilt symptoms should be destroyed along with their suckers, no matter how healthy these suckers may appear.

**Country: Kenya**

Mbaka, J.N.; Waiganjo, M.M.; Kinyua, Z.M.; Amata, R. L., Otipa, M. J., Kahinga, J.; Kuria, S.Ngare, B.M; Wepukhulu, S.B.

**Bacterial *Xanthomonas* wilt technology transfer:**

Training on field and laboratory diagnostics of banana *Xanthomonas* wilt at Makerere University, Kampala, Uganda, 28th July to 1st August 2008

The course content of the training undertaken by Jeseca Mbaka at Makerere University, Uganda was on field diagnostics of BXW with emphasis on its distinction from fusarium wilt and molecular tools for diagnosis from symptomatic and asymptomatic samples. This was organized and facilitated by the IPM-CRSP. The trainer, Geoffrey Tusiime of the Department of Crop Science at Makerere University, and one of his M.S. students, Scovia Adikin,i gave a very comprehensive session on both the field and laboratory diagnostics of BXW. Laboratory exercise on DNA extraction from banana tissues, preparation of material and running of PCR, and gel electrophoresis were very clearly done. The trainer returned to Kenya satisfied that she had understood molecular detection and would disseminate the information to other interested parties.

**Highlights**

A plant pathologist was trained on the field and laboratory diagnosis of banana *Xanthomonas* wilt (BXW). Molecular disease detection techniques (DNA extraction, running PCR, gel electrophoresis) were acquired.

The country's capacity in preparedness for BXW mitigation in case of an epidemic was strengthened.

The trainee became a trainer for more people for effective management of BXW in Kenya.

Banana (BXW) technology dissemination to district extension officers in Central Province and researchers was an important part of the training program.

The overall objective of the IPM-CRSP training program was to strengthen capacity in the Central Province of Kenya to sustainably manage banana *Xanthomonas* wilt outbreaks.

Capacity of key personnel from six districts in the Central Province of Kenya for BXW diagnostics and management was enhanced and training materials were disseminated (starter kits for each district).

Researchers and extension field workers were equipped with skills, knowledge, and tools for sustainable management of BXW at the farm level. An early warning/surveillance system was established to facilitate timely response/actions against the BXW epidemic.

Information materials (CD's and handouts on management of BXW) were disseminated to all of the stakeholders.

The training facilitated the provincial framework (Provincial Action Plans) with strategies for the control and management of BXW and other banana pests and diseases.

## Coffee

### Country: Uganda

P. Kucel, J.P. Egonyu and R. Wekono; S. Kyamanywa J. Kovach, M. Erbaugh

Biological Monitoring

A seaso-long biological monitoring of Arabica coffee pests in the Mt. Elgon districts of Manafa, Mbale, and Sironko was conducted.

Antestia bugs, stem borers, root mealybugs, coffee berry borer (CBB), scales, and canopy mealybugs were the most common insect pests of coffee, while coffee berry disease (CBD) and coffee leaf rust (CLR) were the most common coffee diseases in the area.

Pest and disease spectra (diversity) at lower (<1500m a.s.l) and higher (≥1500m a.s.l) elevations were largely similar

There were significant negative correlations between incidence of stem borers, leaf skeletonisers, lace bugs, berry borer, and scales to elevation, implying fewer occurrences of these pests with an increase in altitude. The incidence of coffee berry disease, on the other hand, significantly positively correlated with elevation.

**IPM options for control of coffee root mealy bugs and stem borers**

Use of soil applied pesticide (carbofuran), mineral and organic fertilizer application, and use of bean intercrop were evaluated for control of root mealybugs in the Sironko district. Stem wrapping using banana fibers, stem smoothening, and stem banding were tested for control of stem borers.

Soil application of carbofuran granules, CAN fertilizer, and animal manure all significantly reduced the incidence of coffee root mealy bugs.

Smoothening of coffee stems significantly reduced the incidence of coffee stem borers.

Yield assessment for both experiments to determine the yield advantage of each treatment has just began and will continue till the end of the main harvest.

Infrastructure for in-vitro studies on biopesticides and parasitoids of antestia bugs have been set up at Kituza and studies have begun.

**Priority pests and diseases:**

The most important insect pests in order were coffee stemborer (*Bixadus seirricola),* antestia bug, (*Antestiopsis spp*.), coffee berry borers (*Hypothenemus hampei*), and lacebugs (*Habrochila* spp.). The most important diseases in order were leaf rust (*Hemileia vastatrix*) and coffee berry disease (CBD) *(Colletotrichum kahawae*). It should be noted that 29 (23%) farmers were unable to provide any examples of coffee diseases. The overwhelmingly most important weed indicated was couch grass (*Digitaria scalarum*); with other important weed species being *Oxalis latifoli, and* Galisonga.

In an attempt to refine and target research priorities, the relationship between zone and pest constraints was examined. Most pest species were significantly associated with a zone except for coffee berry borer, couch grass, and galisonga weed. Coffee stem borer and leaf rust were clearly associated with lower zone and antestia bug, lace bug, coffee berry disease, and oxalis were clearly associated with higher zone.

**Distribution of *Colletotricum kahawae* the causal agent of the coffee berry disease (CBD)**

Genetic and cultural characterization of *Colletotricum kahawae*, the causal agent of coffee berry disease (CBD), which is one of the most important diseases of Arabica coffee (*Coffea inoculu* L) in Uganda, was the primary focus.

A total of 30 isolates of the CBD pathogen were obtained and purified into culture on minimal and malt extract agar medium as single spores and are being used for molecular characterisation, using Puhala's vegetative compatibility grouping (VCG) approach. In the Kabale and Kisoro districts where coffee cultivation was at higher altitudes (>1700 masl), it was apparent that the mountainous nature and westerly location created favorable conditions for CBD development, which led to highly devastating effects with losses sometimes above 90%.

**Impact Assessments of IPM activities**

J. Bonabana-Wabbi, B. Mugonola, S. Kyamanywa, R. Namusisi, M. Waiganjo, R. Ssonko, Z. Muwanga, S. Musana, M. Otim, D. Taylor, and J. M Erbaugh.

**Establishing Arabic coffee production budgets in the mountain Elgon region of Uganda:**

Information for the analysis of coffee production costs were collected from the coffee growing areas of the Mbale, Sironko, and Manafwa districts in eastern Uganda.

Production budgets indicate that most farmers incurred more labor costs than buying inputs. Labor alone accounted for over 60% of all the production costs in Mbale, Sironko, and Manafwa. The most labor intensive activities were during pruning, weeding, harvesting, applying chemicals, and pulping. Farmers reported a decline in yields, which they attributed to high disease and pests burden on the coffee trees, reduced soil fertility, and aging of the coffee trees. The farmers also reported the lack of a clear pest and disease control schedule, and they did not have adequate knowledge of the effective pesticides to use.

**Country: Tanzania**

**Biological monitoring**

The study was conducted in Hai and Moshi district villages. In each district, three villages (Mlama, Lyamungu Sinde, and Lyamungu Kati in the Hai district, and Ruwa, Makami Juu, and Kyou in Moshi district) were selected. Five farms were selected in each village and on each farm nine randomly picked coffee trees were checked for prevalence of pests with special interest in white coffee stem borer (WCSB), antestia bug, and berry borer.

WCSB and antestia infestation increased noticeablybetween September and November, while CBB dropped to the lowest by November.

**On-station trials for IPM in coffee**

Two trials were conducted on-station using RCBD with three treatments (neem leaf extract, fishbean leaf extract, and selecron check) replicated three times to assess the efficacy of two fresh botanical leaf extracts in the control of scales and thrips. The trial was also replicated in a farmer's field at Uswaa North. For four weeks, weekly assessment of live and dead insects was done.

The population of live thrips was reduced to well below 20 in all treatments, decreasing from a range of 100-150 in a period of 28 days. For the control of scales, both botanical extracts were comparable to the industrial check selecron (Figure 6.2).

**Coffee baseline survey in Mbinga and Mbozi districts**

A baseline survey using a structured questionnaire was carried out in 175 farmsteads in selected villages in Mbinga (Ruvuma region), and the Mbeya, Mbozi, and Rungwe districts (Mbeya region) in the southern highland zone of Tanzania.

It was noted that only 15.4% of respondents have a basic idea about IPM, 24.6% having a slight idea, and 60% have no idea about IPM. Another 56% of respondents showed to be aware of at least some negative effects of using synthetic pesticides. The pest situation in this zone was seen to be more or less similar to the one in the northern zone (Hai and Moshi districts).

**East Africa website portal**:

http://www.aaec.vt.edu/ipmcrspuganda/IPMCRSPEA

This portal was created and is maintained by Dan Taylor, VT.

The website continues to be updated on a regular basis with minutes of meetings, meeting presentations, and reports of research activities as they are made available to the webmaster. The webmaster maintains a listserv of the lead researchers in each country and in the U.S. as well as a listserv of other researchers at the sites and other parties interested in the regional project.

# West African Regional Consortium of IPM Excellence

*Donald E. Mullins, Virginia Tech*

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**Devlopment of an online whitefly monitoring system**

Whitefly-transmitted geminiviruses (WTG) are important constraints in the production of crops such as tomatoes and green beans in the West Africa region. Recently, the use of virus-resistant germplasm and small-scale implementation of host-free periods have been attempted in Mali for the management of WTG. Some success has been achieved with these approaches. The use of a host-free period was found to be most appropriate only within localized areas where traditionally there was a lapse in crop production during parts of the year (e.g., in Baguineda, Mali). Two virus-resistant tomato varieties have been identified and allow for increased tomato production in Baguineda.

**Implementation of the first full season of the whitefly monitoring system and analysis of data acquired to date**

Spatial sampling of whitefly populations continued at the three previously identified cropping regions in Senegal (Gorom, Mboro, and Kolda). The spatial data collected on immature whiteflies in crop fields showed that whitefly populations at Gorom and Mboro were similar and higher than at Kolda. For example, during a seven-month period the mean (± SE) immature densities on crops at Gorom and Mboro were 2.68 (± 0.43) and 2.54 (± 0.42) per sq. cm of leaf, respectively. The density of whiteflies on crops at Kolda during the same period was 0.93 (± 0.17) per sq. cm of leaf. On weeds, immature whitefly densities were lower than on crops; mean (± SE) densities were 0.25 (± 0.07) at Gorom, 0.05 (± 0.01) at Mboro, and 0.17 (± 0.04) at Kolda. In January 2008, at Mboro and Kolda sites whitefly numbers varied among fields and crop types sampled with the heaviest infestations observed on solanaceous crops, particularly bitter eggplant, sweet peppers, and tomatoes. As part of our objective to regionalize whitefly management in the West Africa region, whitefly monitoring was expanded to Mali using methods similar to those used in Senegal. Two cropping regions were selected in Mali (Kati and Beguineda) where data on whitefly populations were collected. In general, whitefly densities on both crops and weeds are lower at the Mali sites than at any of the cropping regions in Senegal. At Kati, mean (± SE) density of immature whiteflies on crops and weeds were 0.30 (± 0.10) and 0.04 (± 0.02) per sq. cm leaf, respectively. At Beguineda, immature densities on crops and weeds were 0.83 (± 0.30) and 0.08 (± 0.03) per sq. cm, respectively.

**Understand socioeconomic and agroeconomic aspects of tomato production**

The baseline survey of tomato growers has been carried out through interviews using a questionnaire developed by ANCAR, Senegal. Survey questionnaires for scientists and industrial experts for the *ex-ante* impact assessment were distributed to target experts in the study areas. ANCAR will collect the completed questionnaires for firs-hand data analysis, and modeling will be done by IITA and

ANCAR as a joint capacity building exercise in impact assessment using economic surplus models.

**Harmonisation of data collection instruments**

To complete the baseline study, data collection instruments used for the baseline surveys in Mali have been adapted for Senegal in collaboration with ANCAR. The first step of the surveys was training enumerators on the questionnaires being used for data collection. The curriculum of this training was mainly the development of a baseline questionnaire on tomato virus problems which emphasizes tomato leaf curl viruses and strategies developed and promoted to control the disease. The second theme was a pesticide safety training questionnaire to assess the level of knowledge and awareness of producers about chemical pesticides.

**Study area**

Surveys were carried out at four (4) sites across the 22 districts of Senegal where tomatoes aremostly produced and where producers rely exclusively on chemical pesticides to control pests and diseases on vegetables. Sites include Thiès, Louga, Saint-Louis, and Dakar, which provide 90% of the total production of vegetables in Senegal.

**Sampling and surveys**

Tomato producers were stratified across the four sites by indicators such as gender and production systems. A sample of 271 tomato producers were interviewed across the four production sites. Table 1 shows the distribution of the sample of producers according to gender.

**Sociodemographic profile of farmers**

Results indicated that 17% of tomato producers attended only primary school or have basic education, 14% completed secondary education, and 15% were schooled in adult education (local language). Half of the farmers lacked basic education. The age of tomato producers varies between 42 and 48 years. The main vegetables produced in the study area are tomato, cabbage, onion, eggplant and African eggplant, commonly called "*Jaxaatu*" (Table 2). The most common tomato varieties grown are Mongal, Xina, M'Boro and Small fry, respectively cited by 38%, 33%, 12% and 10% of respondents. Gempride and Rio Fuego were also grown in some areas of Senegal.

**Tomato production systems**

**Tomato production season**

Tomatoes are produced during three main seasons in Senegal: cold season, dry and warm season, and rainy season. Dakar is the exception, where the level of tomato production is low during the cold season, tomato production in the other sites is higher during the cold season compared to other seasons. Tomato production is constrained during the dry season by water availability. In the rainy season, there is a competition between crops for land allocation. Producers cultivate main crops during the rainy (main) season including rice, cotton, and maize. Tomato field size varies on average from 0.58ha to 1.56ha. The size decreases significantly during the rainy season.

**Farmer perceptions and knowledge of tomato pests and pest intensity**

**Farmers' pests and diseases control methods**

Almost all vegetable producers (97%) in Senegal rely on chemical pesticides to control pests and diseases on vegetables. The most common pesticides used by vegetables producers in Senegal are Dimethoate, Mataphos, Lanate, and Tamaron. Other chemicals are also used and are listed in Table 3. The major sources of pesticides used are pesticides dealers (54%), fellow farmers or parents (37%), and extension agents (32%) as mentioned in Table 4.

Table 1: Distribution of producers according to gender

| Sites | Male | Female | Total |
|---|---|---|---|
| Dakar | 64 | 7 | 71 |
| Louga | 73 | 7 | 80 |
| St. Louis | 76 | 0 | 76 |
| Thiès | 42 | 2 | 44 |
| TOTAL | 255 | 16 | 271 |

Table 2: Main crops grown by vegetable producers

| Vegetables | Dakar | Louga | St Louis | Thies |
|---|---|---|---|---|
| Tomato | 26.0 | 29.2 | 28.0 | 16.2 |
| Cabbage | 13.0 | 18.8 | 1.8 | 12.9 |
| Onion | 6.0 | 25.1 | 24.4 | 8.1 |
| Eggplant | 6.0 | 1.1 | 2.6 | 9.2 |
| Jaxaatu | 6.0 | 7.0 | 0.7 | 1.1 |
| Carrot | 1.0 | 6.6 | 0.0 | 0.4 |
| Okra | 1.0 | 0.4 | 3.7 | 2.6 |
| Green Bean | 1.0 | 0.0 | 0.0 | 0.4 |

Table 3: Most commonly used pesticides

| Names | Frequency (%) (n = 271) |
|---|---|
| Dimethoate | 39.6 |
| Métaphos | 36.9 |
| Lanate | 16.9 |
| Tamaron | 14.9 |
| Décis | 8.8 |
| Dicofol | 7.3 |
| Keltane | 7.1 |
| Soufre | 7.1 |
| Confidor | 5.1 |
| Malathion | 3.7 |
| Manebe | 3.7 |

Table 4: Source of pesticides use advice

| | Frequency (%) (n = 271) |
|---|---|
| Pesticide retailers | 53 |
| Fellow farmers/Parents | 37 |
| Extension agent | 32 |
| FFS | 9 |
| Own Experience | 5 |
| NGO | 1 |
| Industrials | 0,4 |
| No answer | 7 |

Table 5: Techniques used to control virus

| | Frequency (%) (n= 271) |
|---|---|
| Pesticide application | 85 |
| Use of tolerant variety | 26 |
| Crop rotation | 25 |
| Time of planting | 19 |
| Host free period | 8 |
| Nets for seedlings in nursery | 8 |
| No answer | 5 |

**Virus control methods used by farmers**

Chemical application remains the main plant protection measure for 85% of vegetable producers to control viruses on tomatoes in Senegal. Farmers rely more on pesticides because of the lack of alternative measures and relevant information to control tomato viruses. Twenty-six% of farmers use virus tolerant varieties of tomato while 25% prefer using crop rotation. Planting date or a host-free period is also used as an alternative method to control virus infestation. Only 8% of farmers were aware of the host-free period and use it when planting tomatoes. Few farmers (8%) use nets for seedlings in the nursery (Table 5).

**Pesticide application and protection measures**

Using a face mask was the most common protection measure used when preparing and applying pesticides for 48% of tomato producers; whereas 32% of producers spray pesticides without any protective measures. Gloves and protective clothing were also used by 38% and 33% of farmers, respectively. After spraying tomatoes, pesticide containers were disposed of by more than 80% of farmers. Pesticide containers are burned, buried, or thrown away. Only 12% of farmers recycle pesticide containers for household chores.

**Farmer experiences with FFS training on IPM**

Farmers' decision making may be affected by their participation in IPM training and the level of contact with extension. Tables 6 and 7 indicate the amount of contact, and the proportion of farmers who have participated in FFS training on IPM. Results indicate that almost half of the interviewed tomato producers have been contacted by the extension agent to discuss pest management problems and the other half have not been visited. The level of participation in FFS training for IPM is relatively low. Only 29% of tomato producers interviewed have participated in the farmers' field school training.

**This study concludes that:**

- The level of education of interviewed producers is relatively low
- The vegetable production system including tomatoes is diversified and affects the share of land allocated to this crop
- Most of the producers rely on improved tomato varieties due to the increase in pest attacks
- Tomato producers rely on chemical pesticides to control pests, virus problems, and diseases on tomatoes as they have no alternative
- The main source of chemical pesticide purchase is dealer
- There is a need for sensitization and training of tomato producers in the best and safest way to use of pesticides.

Table 6: Proportion of farmers visited by an agricultural extension agent

| | Farmers who have been visited | Farmers who have not been visited | No answer |
|---|---|---|---|
| Frequency (n = 271) | 48% | 47% | 5% |

Table 7: Proportion of farmers who have participated in FFS training for IPM

| | Participation in FFS training for IPM | No participation in FFS training for IPM | No answer |
|---|---|---|---|
| Frequency (n = 271) | 29.2% | 69.4% | 1.5% |

**Finalize and implement a plan for collaboration with the Global Themes projects on diagnosis of insect transmitted viruses in tomatoes and other vegetable crops**

**Development of an IPM package for viral diseases on tomato**

Field trials designed to identify tomato varieties resistant or tolerant to geminivirus transmitted by the whitefly were conducted using a total of 11 varieties of tomatoes and a control (Roma). On-station (Koulikoro, Sikasso, and Sotuba) varieties tested included Athyla, Dennolino, Espadilha, Porfyra, Sensi, and Setcopa. On farm (Sotuba and Koulikoro) varieties tested were Bybal, Gempride, Atack, HA 3060, and HMX 4810. The severity of infection was determined based on the scale developed by Cornell University Other agronomic parameters evaluated included total yield t / ha, the number of plants harvested, the number of fruit / plant and number of fruits / cluster, the average length, width average and the average weight of fruit as well as the impact from attacks by other diseases and insects on the plants. The six tomato varieties tested at the stations were relatively tolerant to the virus. In terms of performance, the best varieties were Sensei, Athyla, Porfyra, and Setcopa. At Sikasso, all new varieties survived virus attacks better than Roma. The five varieties tested were much appreciated by the farmers.

**Expantion of the testing of host-free periods in new places in Mali**

A joint program between IICEM/USAID and IPM, in collaboration with IER and OPIB, was carried out by: (i) training extension office agents on the IPM package developed against tomato leaf curl disease, (ii) informing and convincing the farmers from the 22 villages during meetings organized in each village and establishing a brigade to check for violators and to convince themto destroy illegally planted tomatoes and peppers, and (iii) surveying activities in the exchange of information with both farmers and extension agents.

Results of these planned activities were: (i) the training of 40 agents on the IPM package developed against tomato leaf curl disease, (ii) farmers gaining a better understanding of the IPM package and their willingness to adopt the host-free period on June and July instead of July and August, (iii) the adoption of the host-free period by 22 villages compared to 16 villages in the past, (iv) the destruction of 58 ha tomatoes and peppers by village brigades thatwere charged with checking for tomatoes and peppers during the host-free period, (v) the identification of a few cases of violators (peppers and tomatoes). The end result of these activities created a great motivation and involvement of farmers for the application of the host-free period. The success of this IPM package will increase the acreages and productivity in the area.

**Development of a database and compilation of geographic and temporal data on weeds in the region and their propensity to host whiteflies and viruses**

The goal of developing a website interface for identifying weeds of West African vegetable production has been expanded to include a pocket guide to weeds that can be used by technicians who are working in the fields to survey whiteflies on crops and weeds. Daouda Dembélé has generated 213 photos representing various life stages of dozens of the most common dicotyledonous weed species found in and around vegetable fields in Mali.

**Coordination of data tabulation of information from the Diagnostics Lab and the Insect-Transmitted Viruses Global Themes to the West Africa Regional IPM Website**

The facilities at AVRDC are satisfactory for developing a diagnostic laboratory in Bamako, although equipment is lacking. The staff is qualified to do such work. There is also a chance to have a diagnostic lab at the IER research station at Sotuba. A new building for molecular work is being constructed.

**Studies on cropping systems fruits and vegetables in Guinea**

The socio-economic survey of horticultural activities was finalized in four villages around Kankan (Karifamoriah, Bankalan, Balandou, and Tintioulékoro). Vegetables are very important in the crop production system. They are exclusively grown by women, cultivated in plains and in low-lying areas from October to May. Women associations were formed and some of them in Balandou, Karfamoriah and Bankalan received support from donors such as the World Food Program. Watering the fields by hand requires a lot of labor in most cases. The watering of some perimeters in Balandou and Karfamoriah is done from motor-driven pumps installed on the Milo River.

Cowdung and farm manure are the most used fertilizers. Availability of equipment is low and only 35% of the population possesses the minimum equipment. Herbicide use is common and sprayers are available on some farms. Vegetables are sold on the local markets in Kankan for farmers from Balandou, Tintioulénkoro, and Karfamoriah, and in Batè-Nafadji and Soumankoï for farmers from Bankalan. In the four villages, vegetable growing is the main income-generating activity for women.

Surveys were carried out on vegetables including cabbage to follow-up on pest importance and traditional control methods. The main pests identified were borers on cabbage and viruses on tomatoes. Pesticides were seldom used to control these pests. The recommendation was to review the growing period in order to avoid the pest prevalence. Cashew nut planters from 10 villages in Balanbou and Karfamoriah were selected for the IPM experiments and implementation of the network. The results indicated that several borers invaded the cashew nut tree but needed to be identified. In 2008, the infestation was low and only 3% of the trees were damaged by the borers. No pesticide is being used to control the borer infestation.

**Investigation of pests of potato in storage and propagation**

Potato is not a staple crop in the region, but it is a very important market vegetable. Potatoes are imported from Europe and also grown for local consumption in Mali, Guinea, and Burkina Faso from imported seed potatoes. Senegal has a small European export market for a dwarf variety. The cost of imported seed potateso is approximately 50% of the production costs for a Malian farmer. A university laboratory in Mali already has capacity for high quality tissue culture propagation. There is interest in producing virus-free seed potatoes in northern Mali to supply the national and perhaps regional market. However, there are a number of non-technical components to creating a viable business model.

**Incidence and abundance of potato tuber moths**

In Senegal and Guinea, potato is cultivated twice a year. The early season commences in November and the crop is harvested about February, while the late season crop is cultivated in March and harvested between May and June. Infestation of the early crop by the potato tuber moth (PTM) is light. Infestation of the late crop by the same moth is very heavy. Infestation commences in the field and infested tubers are carried into storage where infestation continues. The PTM attacks all the phenological stages of potato, from vines to tubers. The shoot of the potato crop is attacked first. Eggs are laid in the soil and hatched larvae burrow into the ground where they locate and burrow into tubers to complete development. The incidence and abundance of the potato moth has also been worked out for Guinea. During the summer months of 2007, the data on the dynamics of potato tuber moth was generated through a survey. A map of potato cultivating areas and diseases or pests associated with potato was produced for Guinea and Senegal.

**Biology and food preference of the potato tuber moth**

The adult moths copulate three-six hours following emergence. Eggs are laid on potato tubers. The larvae hatch and burrow into potato tubers, where they create feeding tunnels. The duration of life history, from egg deposition to adult emergence, takes from 24 to 33 days under laboratory conditions. The other crops infested by the PTM include tomatoes and egg plant, and they serve as refugia for the moth. The incidence of the moth was also determined on these crops. All the phenological stages of these crops are attacked by PTM.

**Acclimatization and multiplication of microtubers (potato seeds) from France and Netherlands**

In Guinea, potato seeds have been produced from imported potato tubercles of three varieties that have been tested and are less susceptible to rot. These new varieties sustained very slight damage to bacterial, viral, and fungal damage. The seeds are also considerably smaller than the imported ones. One of the major difficulties encountered by Senegalese potato scientists was generation of potato seeds from microtubers. This is because the microtubers have to be planted for two seasons to get potato seeds that will be distributed or sold to the farmers. PTM severely limits the production of potato seeds from microtubers in Senegal.

**Quality Assurance: Pesticide safety education**

**Development of additional pesticide safety education program support materials**

Three new lesson plan drafts were written in 2007-2008: 1). Understanding and Using the Pesticide Product Label; 2). Pesticide Storage; and 3). Pesticide Handling Decisions – A Safety Checklist. Two of these are posted on the IPM CRSP website in both English and French: Pesticide Storage and Pesticide Handling Decisions – A Safety Checklist.

The Understanding and Using of the Pesticide Product Label lesson plan includes a number of graphics and is in the process of being designed.

**Pesticide safety education programs**

In 2008, IER conducted training on the safe use of pesticides in seven new sites: 1). Four in conjunction with farmer field schools in villages in the Sikasso and Segou regions for mango and cowpea production, and 2). Three programs dedicated specifically to pesticide safety in villages near Bamako that have not, to date, received "basic safety" training. In the same time period, OHVN conducted a three-day "train the trainer" session for WACIP (West Africa Cotton Improvement Program) field agents as well as multiple village-based programs for cotton growers in the OHVN zone.

**Technical assistance to pesticide safety educators in West Africa**

Hipkins, Gamby, and Sidibé visited pesticide safety trainers in Senegal in July 2008 to: 1). "network" and encourage Senegalese participation in pesticide safety education programs; 2). Open lines of communication between interested parties in Senegal; and 3). Show practicing and prospective pesticide safety trainers from Senegal materials and methods developed in Mali. All agency representatives contacted (DPV, ISRA, FAO, ANCAR, PAN, SAGIC, and SEPAS) expressed their appreciation for the Mali team's visit, and stated that they are ready to participate in this activity.

**Pesticide residue training: Intra- or inter-laboratory method validation or other study using the Quechers method for pesticide residue analysis of fruits and vegetables**

In addition to work sessions with pesticide residue chemists in Mali and Senegal, hands-on Quechers work sessions were held at the Environmental Toxicology Quality Control Laboratory (ETQCL) in Bamako and at CERES/Locustox in Dakar. Eight men and five women participated at the ETQCL work session, and three men and four women (including two from the first group) participated in the second session at Locustox. The work session at the ETQCL included extraction of mango using the Quechers method and trouble-shooting previous problem areas with sample extraction and analysis. The "official" work session was hosted by CERES/Locustox in Dakar, Senegal. Chemists from Mali and Senegal, which are collaborators in the IPM CRSP West Africa project, participated in an intensive five-day, hands-on extraction of fruits and vegetables using the Quechers method. Tomatoes, mangoes, and green beans were purchased from local markets and "spiked" at the 0.1 and 0.5 mg/kg levels with pesticides to evaluate the accuracy and precision of "recovered" pesticides using a modified Quechers method. The pesticides gamma-BHC (Lindane), toclophos-methyl, and lambda-cyhalothrin were selected as representative pesticides of interest. "Blank" samples of each commodity were also extracted for comparison. The percent recoveries of "spiked" tomato, mango, and green bean samples (n = 50) were between 88-119% for three pesticides in three commodities with good repeatability (6% RSD). Comparison of bulk chemicals weighed in-house and purchased chemicals showed that inexpensive bulk chemicals provided acceptably clean extracts if convenience and time saving with purchased, pre-weighed chemicals isn't possible. A second comparison of external and internal calibration to analyze data after gas chromatographic instrument analysis demonstrated the value of using internal calibration. The hands-on exercise yielded successful results and chemists from both laboratories are optimistic about completing an intra- and inter-laboratory method validation this year using a shared protocol. The Quechers method is increasingly used by regulatory, industrial, and contract laboratories for testing food commodities. Completing a Quechers validation would prepare both laboratories to participate in proficiency testing, an integral step on the road to accreditation to ISO 17025.

**West Africa Pesticide Programs (http://wapp.biochem.vt.edu) web site**

The web site provides a central location for chemists to access information and showcases the activities of pesticide residue chemists to various stakeholders.

# Regional Integrated Pest Management Research and Education for South Asia

*Ed Rajotte, Penn State University*
*George Norton, Virginia Tech*

**Co- Investigator:**
Sally Miller, The Ohio State University
**Host Countries:** Bangladesh, India, Nepal
**Collaborators:** Tamil Nadu Agricultural University; The Energy and Resources Institute, India; Bangladesh Agricultural Research Institute, IRRI; Nepal Agricultural Research Council, SIMI, Nepal; IRRI; Impact Assessment Global Theme.

**Regional and International Communication**

Networking is accomplished in Bangladesh through collaboration with the host country institutions, such as BARC, BARI, BSMR Agricultural University, CARE-Bangladesh, Mennonite Central Committee (MCC), Action Aid-Bangladesh, Practical Action-Bangladesh, Winrock International-Bangladesh, and IRRI-Bangladesh. Networking among countries within the region (Bangladesh, India, and Nepal) is accomplished through program planning, work-plans, and information exchange on IPM technologies. The site coordinators also play a role in networking among different host countries and foreign supported projects through hosting scientists from other sites and attending meetings that are represented by various organizations within and among countries as described below. The Manila meeting helped in networking this past year.

Communications among countries within the region are accomplished by site visits of U.S. partners, visits and cross training among country participants and, extensive electronic communications.

**Collaboration with global theme projects and regional centers**

Primary collaboration occurred with the Impact Assessment global theme on which a thesis was completed on the economic impacts of the pheromone technology in gourds developed and transferred through the IPM CRSP in Bangladesh. Collaboration also occurred with Topsovirus global theme in India. A separate grant received as part of the Agricultural Knowledge Initiative, a collaboration between India and the U.S., will enhance work on insect-borne plant virus research.

**IPM technology development**

**Bangladesh:**
**Survey for assessing pest status of mite species and to develop an IPM package for their management**
S. N. Alam, N. K. Dutta, M. K. Uddin, A.N.M. R. Karim, and E. G. Rajotte

The red spider mite, *Tetranychus* spp., has recently appeared as one of the major pests in different vegetables causing serious damage. Outbreaks of red spider mite are believed to have resulted from injudicious use of pesticides, particularly pyrethroid insecticides. In order to develop an IPM package for its control, surveys were conducted in four major vegetable growing areas to assess its pest status in seven vegetable crops such as eggplant, cucumber, bitter gourd, teasel gourd, ribbed gourd, snake gourd, and aroids during both winter and summer seasons.

The experiments to develop IPM tactics to control red spider mite were carried out on eggplant (variety ‘Singnath’), the most frequently affected crop, in farmers’ fields of the Narsingdi district during the 2007-2008 summer season. As predators of mites or other potential natural enemies were unavailable, one botanical insecticide (Neem seed kernel extract- NSKE), one pyrethroid insecticide, and three miticides were tested to compare their efficacy in controlling the red spider mite.

Survey results showed that red spider mite incidence was highest on eggplant, followed by cucumber, aroids, ribbed gourd, and teasel gourd during the seasons. No infestation was observed in bitter gourd. Damage severity was highest in Jessore area on all crops, followed by Narsingdi, Comilla, Natore, and Bogra. Fields receiving frequent insecticide applications had a population of mites (56.2 mites per leaf) 15 times higher than the fields receiving no insecticide applications (4.4 mites per leaf).

### Evaluation of eggplant and tomato germplasms for resistance to fruit and shoot borer (FSB), jassid, bacterial wilt (BW), and root-knot nematode (RKN)

Shahabuddin Ahmad, M. A. Rahman, M. S. Nahar, A. K. M Khorsheduzzaman, Jamil Chowdhury, Latifa Yasmin, Mahrufa Afroz, A.N.M.R. Karim, Sally Miller, and E. G. Rajotte

Fruit and shoot borer (FSB), jassid, bacterial wilt (BW), and root-knot nematode (RKN) are the major damaging pests of eggplant. Tomato production is also seriously affected due to the damage caused by BW and RKN. The farmers apply various pesticides indiscriminately without knowing the pest, or achieving any satisfactory control of the pests. Several resistant eggplant and tomato lines were identified by carrying out research in previous years. Through repeated selection and confirmation of resistance, three eggplant varieties having multiple resistances to FSB, jassid, BW, and RKN were released in 2006. These are BARI Begun-6, BARI Begun-7, and BARI Begun-8 ('Begun' means eggplant). These varieties are now being demonstrated in different sites through BARI and extension programs of the Department of Agricultural Extension.

All the experiments were conducted at BARI farm, Gazipur. The evaluation against FSB was done in the field under conditions of natural FSB infestations. The evaluations against BW and RKN were carried out in sickbeds infested artificially with BW inoculums and RKN. The BW sickbeds contained *Ralstonia solanacearum* bacterium having a population density of $1.7 \times 10^8$ CFU/ml of water by dilution plate method. The RKN sickbeds were prepared containing 2,000-3,000 RKN larvae per kg of soil in the winter season and 3,000-4,000 RKN larvae per kg of soil in the summer season.

**Evaluation of eggplant against FSB**: Out of 15 test lines, eight lines (Bholanath, BD-2680, BD-2681, BD-2682, BD-2683, BD-2689, Jamalpur-3, and BB-332) were selected based on their better resistance to FSB, jassid, BW, and fruit yield. These lines will be further tested for confirmation of their reactions to different pests and diseases.

**Evaluation of eggplant and tomato lines against BW**: Thirteen summer eggplant lines and 22 winter eggplant lines were evaluated in BW sickbeds. Only one line each of the summer (EGN-06) and winter (BD-2684) eggplant accessions showed moderate resistance.

Nineteen summer and 26 winter tomato lines were evaluated against BW in sickbeds. Two showed resistance and four showed moderate resistance reaction. Among 26 winter tomato lines, two exhibited moderate resistance.

**Evaluation of eggplant and tomato against RKN**: Seedlings of 20 eggplant and 31 tomato lines were transplanted separately in sickbeds. Two were resistant and six were moderately resistant. Among 31 tomato lines, only two exhibited resistance.

Results of the experiments have shown that eggplant and tomato germplasms having genetic resistance to BW and RKN are available and these could be used as farmer varieties.

### Development of pumpkin variety resistant to PRSV and WMV2 viruses

M. A. Rashid, M.A.T. Masud, A.K.M. Quamaruzzaman, M. Zashim Uddin, A.N.M.R. Karim, and Sally Miller

The production of pumpkin, a popular vegetable in Bangladesh, is seriously constrained due to the attack of a complex of viruses, particularly the papaya ring spot virus (PRSV) and watermelon virus-2 (WMV2).

Several pumpkin lines having resistance to a complex of viruses including PRSV and WMV2 were selected in previous years through field evaluation and the ELISA test. Among them, two virus-resistant lines having good horticultural qualities were recommended and released as varieties by the National Seed Board in 2007.

During 2007-2008, eight pumpkin lines that were selected in the previous years were re-tested for confirming the results. The performance of PKDS-187-6-5-9-6-2 was excellent in respect of virus resistance and horticultural traits. This line has the potential for recommendation as farmers' variety. Two other lines, PKDS-187-9-A-4-6-4-4 and PKDS-16-2-4-1-10-2-2, were also highly promising, but they need further tests for purification and improvement of their homozygosity.

**Development of a virus resistant variety of cucumber (*Cucumis sativus*)**

M. A. Rashid, G. M. A. Halim, M. A. Muquit, A.N.M.R.Karim and Sally Miller

Cucumber (*Cucumis sativus*) is a high-value, popular vegetable in Bangladesh that is grown widely throughout the year. Damage caused by a complex of viruses such as watermelon mosaic virus (WMV), cucumber green mottle mosaic virus (CGMV), and papaya ring spot virus (PRSV) is the main constraint for its satisfactory production.

Twenty cucumber lines that were selected in the previous year and one commercial variety were evaluated at BARI farm. Six lines that had 27-67% virus infection with low and medium disease severity were selected and selfed for further evaluation in the next season. Mite infestation was also lower on the selected materials. The six selected lines were CS-0034, CS-0050, CS-0062, CS-0063, CS-0079, and CS-0080.

**Evaluation of okra germplasms for developing varieties resistant to yellow vein mosaic virus (YVMV) disease**

M. A. Rashid, Shahabuddin Ahmad, M. Zashim Uddin, A.K.M.S.R. Mollik, M. Saifullah, A.K.M. Quamaruzzaman, M. Jamil Chowdhury, M. Harunur Rashid, Sally Miller and Edwin G. Rajotte

Damage to okra due to the attack of yellow vein mosaic virus (YVMV) is the main constraint to its satisfactory production. Local and exotic germplasms available in Bangladesh are believed to possess resistance to YVMV.

During the 2007-2008 summer season, 20 okra germpasms that were selected in the previous year were evaluated at BARI farm, Gazipur. Symptomatically, only six lines (OK-0145, OK-0146, OK-0147, OK-0148, OK-0170, and OK-0212) exhibited a resistant reaction. These lines were selfed and selected for further evaluation.

**Grafting of watermelon with cucurbit rootstocks for controlling *Fusarium* wilt disease**

M. A. Rashid, Shahabuddin Ahmad, M. Tauhidur Rahman, M. A. Rahman, A.K.M. Salim Reza Mollik and Sally Miller

For watermelon (*Citrullus lanatus*), *Fusarium* wilt disease caused by *Fusarium oxysporum* is the main damaging pest, causing heavy damage to watermelon crops every year. Grafting of watermelon onto cucurbit crops such as bottle gourd and pumpkin rootstocks, resistant to *F. oxysporum,* has been found to be effective.

Grafting of watermelon on both bottle gourd and pumpkin rootstocks was highly compatible and successful, producing an average of 90% survival on bottle gourd and 80% on pumpkin rootstocks. No mortality of grafted watermelon seedlings and the rootstocks was observed up to 15 days of planting.

**Development of country bean (*Dolicos lablab*) varieties resistant to pod borer and virus disease**

M. A. Rashid, Rahima Khatoon, Tauhidur Rahman, A. K. M. Khorsheduzzaman, and Sally Miller

The production of country beans (*Dolicos lablab*is was seriously hampered by pod borer (*Maruca vitrata*) and yellow vein mosaic virus (YVMV).

Twenty-eight country bean germplasms that were selected in the previous year were evaluated. Out of 28 test materials, five materials having better reactions to pod borer and YVMV and better horticultural traits were selected. The selected materials will be tested in the next season.

**Development of IPM packages for insect pests of country bean, cabbage, and tomato**

S. N. Alam, N.K. Dutta, M. Akhtaruzzaman Sarker, A.K.M. Ziaur Rahman, M. I. Islam, M. A. Ali, A.N.M.R. Karim, and E. G. Rajotte

Country bean production is seriously constrained due to the damage caused by pod borers (*Maruca vitrata* and *Helicoverpa armigera*). Aphids arealso important pests. Cabbage is mainly damaged by two leaf-eating insect pests: the diamond back moth (*Plutella xylostella*) and armyworm (*Spodoptera litura*). Tomato is damaged by the white fly transmitted tomato leaf curl virus (TLCV) and fruit borer (*Helicoverpa armigera).*

**(a) Trials for Country bean**: IPM package trials compared 1) IPM practice comprising of (a) destruction of infested flowers and fruits by hand picking every other day and weekly release of eggs of the parasitoid *Trichogramma evanescens* at the rate of one gm parasitized eggs/ha/week and larval parasitoid *Bracon habetor* at the rate of 800-1,000 adult/ha/week; (b) weekly release of eggs of the parasitoid *Trichogramma evanescens* at the rate of one gm parasitized eggs/ha/week, and larval parasitoid *Bracon habetor* at the rate of 800-1,000 adults/ha/week; and (c) farmers' practice (Non-

IPM) of foliar spray of synthetic pyrethroid insecticide.

Results of both the years of 2006-2007 and 2007-2008 showed that average infestations of pod borers and aphids were 2.3 to 18 times higher in non-IPM plots than that of the IPM plots. Release of egg and larval parasitoids were also highly effective. The IPM fields produced up to 2.4 times higher yields and reduced pest control costs by 43-45%

**(b) Trials for cabbage**: Treatments included $T_1$-IPM practice consisting of (a) destruction of leaf-eating caterpillars by hand picking from infested leaves, (b) weekly release of egg parasitoid *Trichogramma evanescens* at the rate of one gm parasitized eggs/ha/week, and (c) weekly release of larval parasitoid *Bracon habetor*; and $T_2$-Non-IPM practice of foliar spray with synthetic pyrethroid insecticide

Cabbage heads infested by army worm and diamond back moth were 3-12 times higher in non-IPM fields than in the IPM fields. IPM fields produced about 1.4 times higher yields than that of the non-IPM plots, and the cost of pest control in IPM practice was 1.9 to 2.9 times lower.

**(c) Trials for tomato**: Tomato IPM package trials included 1) an IPM package comprised of (a) use of tomato line 'TLB-182' resistant to white fly and tomato leaf curl virus (TLCV), (b) destruction of infested fruits by hand picking, (c) weekly release of egg parasitoid *Trichogramma evanescens* at the rate of one gm parasitized eggs/ha/week, (d) weekly release of larval parasitoid *Bracon habetor* at the rate of 800-1,000 adults/ha/week, and (e) use of *Helicoverpa* pheromone trap at 10M distances; and 2) Non-IPM practice consisting of (a) use of susceptible tomato variety (BARI Tomato-2), and (b) spraying of synthetic pyrethroid insecticide (Cymbush 10EC at one ml per liter of water) every three days.

Results showed that infestations of fruit borer, white fly, and TLCV were 2.2 to 11 times higher in non-IPM plots than in the IPM plots, and IPM fields produced about 1.4 times higher yields. Costs were 2.2 times higher in non-IPM fields.

### Development of IPM package for management of cucurbit fruit fly (*Bactrocera cucurbitae*) in bitter gourd and ridge gourd crops

M. Yousuf Mian, S. N. Alam, A.K.M. Ziaur Rahman, M. Nasiruddin, A.N.M.R. Karim, and Edwin G. Rajotte

The cucurbit fruit fly, *Bactrocera cucurbitae*, has been successfully managed using a synthetic sex pheromone (cuelure). Eleven kinds of lures/attractants were tested including cuelure strips, cuelure+naled strips, cuelure+LCH strips, formate strips, formate+naled strips, formate+LCH strips, rose wafers, rose+naled wafers, rose+LCH wafers, Kool aids singles, and frape flavor. The synthetic pheromone 'cuelure' was included for comparison.

Results showed that both male and female fruit flies were attracted to all the lures except to the one dispensed with 'cuelure' alone. Among the attractants, cuelure + naled strips, formate + naled strips, and 'rose+naled wafers' trapped higher numbers of male and female fruit flies during both years. However, the lure dispensed with cuelure alone attracted the highest number of male fruit flies

### Study of nematode trophic groups in IPM and Non-IPM systems

M. A. Rahman, M. S. Nahar, Latifa Yasmin, A. N. M. R. Karim, Sally Miller.

All agricultural management systems directly or indirectly affect beneficial and harmful microbial populations in the soil, and soil quality should be managed to maintain beneficials. Soil samples were collected from IPM and non-IPM production systems of the Jessore and Sirajganj areas. At BARI RARS farm, a three-replicated trial was set up with the following four treatments: (a) land preparation by using chemical fertilizers at standard rates; (b) soil incorporation with poultry refuse @ 5t/ha; (c) soil incorporation with mustard oil-cake @ 500Kg/ha; and (d) use of fungal bio-control agent *Trichoderma harzianum* on barley carrier @ 50/pit. In Sirajganj, an experiment was conducted in collaboration with MCC (NGO) in an eggplant field with the following treatments: (a) use of chemical fertilizers at standard rates; (b) soil incorporation with poultry refuse @ 5t/ha; (c) soil incorporation with mustard oil-cake @ 500Kg/ha; (d) vermicompost @ 5t/ha; (e) soil incorporation with neem oil-cake; (f) cowdung @ 10t/ha and (g) use of fungal bio-control agent *Trichoderma harzianum* on barley carrier @ 2g/pit. Collection of soil samples and extraction, identification, and counting of nematodes were done by using standard procedures.

The most prevalent plant parasitic nematodes observed in the Jessore area belonged to the species of *Meloidogyne*, *Hoplolaimus*, *Helicotylenchus,* and *Tylenchus* genera. In the Sirajganj area, the prevalent plant parasitic species belonged to *Meloidogyne*, P*aratylenchus* and *Tylenchus* genera. The fungal feeders belonged to *Aphelenchoides* and *Aphelenchus* genera. The bacterial feeding nematodes were the largest in number that included the species of *Rhabdites*, *Cephalobus*, *Acrobeloides*, *Monohystera*, *Mononchoides* and *Plectus* genera. Two species of omnivorous nematodes (*Aporcelaimus* and *Dorycelaimus* spp.) were more common.

In general, the IPM practices (organic soil amendments with poultry refuse, mustard oil-cake, neem oil-cake, cowdung, vermicompost, or *T. harzianum*) significantly reduced the populations of plant parasitic nematodes and increased or induced the growth of various beneficial (fungal and bacterial feeding) nematodes. Neither the cropping pattern nor the crop production region (e.g., Jessore and Sirajganj) influenced the effects of IPM and non-IPM systems.

**Identification of diseases of summer tomato grown under polythene tunnels- a new cultivation system**

M.A. Rahman, M. S. Nahar, Latifa Yasmin, A.N.M.R. Karim, and Sally Miller

Some tomato varieties can be successfully grown during the summer season (May-October) under plastic tunnels and bring about higher economic returns to the producers.

Surveys conducted in six districts (Pabna, Satkhira, Narail, Rangamati, Sylhet, and Thakurgaon) showed that besides some common diseases, other diseases that are not commonly observed during the winter season under open field conditions were more prevalent during the summer season under the polythene tunnel system. Bacterial wilt (BW), tomato yellow leaf curl virus (TYLCV), and root-knot nematode (RKN) were the common diseases in most of the surveyed areas. BW incidence was very high (78% plants wilted) in Thakurgaon. The diseases that were found to occur in most of the summer tomato fields were tomato spotted wilt virus (TSWV), black leaf mold (BLM) caused by *Pseudocercospora fuligena*, and blossom end rot (BER) caused due to calcium deficiency. Interestingly, collar rot disease caused by *Sclerotium rolfsii,* which was prevalent last year in many of the locations, was not observed this year in any of the surveyed areas. Cultivation of summer tomato under a polythene tunnel has potential risk of inducing some diseases that are usually scarce during the winter season.

**Mass-rearing of parasitoids and their efficacy evaluation in greenhouse and field**

S. N. Alam, M. Akhtaruzzaman Sarkar, A.K.M. Ziaur Rahman, A.N.M. R. Karim, and E. G. Rajotte

During 2007-2008, one species of larval parasitoid, *Bracon habetor*, and three species of *Trichogramma* egg parasitoid (*Trichogramma chilonis*, *T. evanescens*, & *T. japonica*) were reared in the laboratory and tested for parasitism efficiency against eggplant FSB and leaf-eating pests of cabbage in the field under micro-plot conditions.

**Mass-rearing of larval parasitoid, *Bracon habetor***: *Bracon habetor* was mass-reared on grown up larvae (5-6 instar) of wax moth, *Galleria mellonella*. The adults of *Bracon habetor* emerged in 8-10 days (average 9.2 days) starting from the date of parasitism. The number of *Bracon habetor* emerging from each larva of wax moth averaged 5.2. Adults of *Bracon habetor* lived for 21-26 days (average 23.7 days) on honey.

**Mass-rearing of egg parasitoid, *Trichogramma* spp. on the eggs of rice moth, *Sitotroga cerealella***: The present study was undertaken to standardize the mass-rearing protocol of *Tricogramma* spp. on the eggs of rice moth, *Sitotroga cerealella*. Almost all the eggs of rice moth were parasitized in 9-11 days. The parasitized eggs were preserved in desiccators at 3-4$^0$C and 75-85% RH for 1-1.5 months for using them in greenhouse or field trials.

**Determination of parasitism efficiency of *Trichogramma* species on the host eggs of *Sitotroga cerealella* (rice moth) and *Corcyra cephalonica* (rice meal moth)**: The parasitism efficiency of three *Trichogramma* species *(T. chilonis, T. evanescens,* & *T. japonicum*) was evaluated on the eggs of two host insects, *Sitotroga cerealella* and *Corcyra cephalonica,* to ensure that the parasitoids are capable to successfully parasitize the target pests.

Among the parasitoid spp., *T. evanescens* was most efficient, parasitizing 92% eggs of *C. cephalonica* (rice meal moth), followed by *T. japonica* and *T. chilonis* causing 66.8% and 55.8%, respectively. *T. evanescens* was also the most efficient parasitoid on the eggs of *S. cerealella* (rice moth), parasitizing 84.6% eggs, followed by *T. chilonis* and *T. japonicum* effecting 77.6% and 43.8% parasitism, respectively. Emergence of adult parasitoids from the eggs of the two host insects was very high, ranging from 93.2 to 98.1% on *C. cephalonica* (rice meal moth) and 88.7 to 97.1% on *S. cerealella* (rice moth). Emergence of *T. evanescens* was however highest on both the host eggs.

**Parasitism efficiency of two species of egg parasitoid, *Trichogramma chilonis* and *Trichogramma evanescens*, for controlling eggplant fruit and shoot borer (FSB) under micro-plot conditions:** The egg parasitoids, *Trichogramma chilonis* and *T. evanescens*, are widely prevalent in eggplant fields. Replicated micro-plot trials were conducted to determine the efficiency for controlling eggplant FSB using the following treatments: (a) FSB + *T. chilonis*; (b) FS + *T. evanescens*; (c) FSB without parasitoids; and (d) natural FSB infestation without net cover. Twenty days after parasitoid release, the nets were removed and FSB infestation was recorded.

Over three years, shoot infestations in micro-plots with *T. chilonis* FS + *T. evanescens* were consistently lower than the ones without parasitoids, indicating that the two *Trichogramma* egg parasitoids are highly efficient in parasitizing FSB eggs.

**Parasitism efficiency of three species of *Trichogramma* egg parasitoids and one species of larval parasitoid, *Bracon habetor*, for controlling leaf-eating insect pests of cabbage under micro-plot conditions**: Parasitism of the diamond back moth (DBM), *Plutella xzylostella*, and the armyworm, *Spodoptera litura*, was evaluated in micro-plot tests

Treatments included (a) DBM and armyworm + *T. chilonis*; (b) DBM and armyworm + *T. evanescens*; (c) DBM and armyworm + *T. bactrae*; and (d) DBM and armyworm only without parasitoids. The other set consisted of the following treatments containing the pests, egg parasitoid and larval parasitoid: (a) DBM and armyworm + *T. chilonis* + *B. habetor*; (b) DBM and armyworm + *T. evanescens* + *B. habetor*; (c) DBM and armyworm + *T. bactrae* + *B. habetor*; and (d) DBM and armyworm only without parasitoids. The parasitoids were released two days after the pests were introduced within netted micro-plots. Results showed that infestation of cabbage heads by DBM and armyworm was significantly lower in micro-plots where the egg parasitoids were released (12.7% – 19.9%) compared to the control plots (64.4%) without parasitoids. Similarly, the numbers of DBM and armyworm caterpillars recovered from each cabbage head were significantly fewer in micro-plots treated with egg parasitoids.

A combination of egg and larval parasitoids was even more effective, causing significantly lower infestations in micro-plots with parasitoid treatments that ranged from 3.4 to 8.9% as compared to a very high infestation of 61.1% in micro-plots without parasitoids. The numbers of DBM and armyworm larvae recovered from each cabbage head were also significantly lower in micro-plots treated with both egg and larval parasitoids.

**Antagonistic effects of two isolates of *Trichoderma harzianum* in the laboratory for their use in farmers' fields to control soil-borne disease pathogens**

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*Trichoderma harzianum*, 'BARI isolate,' is active against soil pathogens as is another isolate, 'NDS'.

Inhibition (antagonistic) effects of the BARI and NDS isolates against *Sclerotium rolfsii* and *Fusarium* spp. were studied by using 'Dual Culture Technique.' Results showed that both the isolates of *Trichoderma harzianum* reduced the mycelial growth of both the pathogens. The radial mycelial growth of the pathogen *Sclerotium rolfsii* was only 3.0cm and 3.1cm, respectively, in the presence of BARI and NDS isolates, whereas it was 7.5cm in the absence of the *T. harzianum* isolates after 120 hours of incubation. The growth reduction of *S. rolfsii* was 59.5% and 58.2%, respectively, in presence of BARI and NDS isolates. Although the mycelial growth rate of *Fusarium* spp. was relatively slower than that of *S. rolfsii* in PDA medium, both the isolates of *T. harzianum* reduced its mycelial growth significantly.

**Country: Nepal**

**Pheromones and Pheromone traps for multiple crops**

Different pheromones are available in local markets, but the quality is not consistent and there is no technical support from service providers. Poor quality pheromones and traps have caused serious damage to the ongoing value chain approach. Quality control is not institutionalized. Therefore, pheromones from several sources were tested in Nepal.

**Fruit fly in cucumber and tomato--** Standardization of pheromones and traps was carried out in Surkhet, Banke, Rupendehi, Kaski, Lalitpur, and Syanjga project districts in farmers' fields. Cucurbits, tomatoes, eggplant, and coffee were selected. Fruit fly, tomato fruit worm, tobacco caterpillar, shoot and fruit borer of eggplant, and coffee white stem borer infestations were evaluated. Two food lures and 10different types of sex lures were tested: T1; Protein hydrolysate (PH) powder 10g was mixed with 15ml of water and 0.5ml malathion 50 EC was added to the paste. T2; Meshed Sweet Gourd (MSG) was added with 0.5ml malathion 50 EC and kept in a plastic bowel. T3; Poison trap baited with (U.S.) standard Cue-lure 0.5ml in wafers. T4; Poison trap baited with standard (U.S.) Methyl eugenol 0.5ml in wafers. T5; Poison trap baited with standard (U.S.) Cue-lure 0.25ml + Methyl eugenol 0.25ml in wafers. T6; Poison trap baited with *Bactrocera* lure (from local market). T7; Soap water trap baited with standard (U.S.) Cue-lure 0.5ml in wafers. T8; Soap water trap baited with standard (U.S.) Methyl eugenol 0.5ml in wafers. T9; Soap water trap baited with standard (U.S.) Cue-lure 0.25ml + Methyl eugenol 0.25ml (1:1) in wafers. T10; Soap water trap baited with *Bactrocera* lure (from local market). T11; Delta sticky trap with *Bactrocera* lure (from local market). T12; Poison trap baited with Cue-lure (from local market) 0.5ml in cotton pad.

Out of twelve treatments, (T1) mashed sweet gourd (MSG) gave the highest counts for fruit fly trapping, followed by (T5) poison trap baited with standard (U.S.) Cue-lure and Methyl eugenol (1:1) ratio in wafers and (T9) soap water trap baited with standard (U.S.) Cue-lure and Methyl eugenol (1:1) ratio in wafers. Mashed sweet gourd caught five times more flies than protein hydrolysate. The peak period of fruit fly activity on cucurbit seems to be the third week of May in Surkhet. For management purposes, these traps should be placed in the field at least one month before pest occurrence (that is, third week of April). Poor farmers of Surkhet not only benefit from traps as a warning technology, but they may help in mass trapping. Peaks differed among districts.

Poison traps performed better compared with soap water and delta sticky traps in attracting fruit flies on cucurbits in Surkhet with poison and soap water traps performing better than delta sticky traps. Delta sticky traps are expensive and soap water traps are eco-friendly and non-hazardous to health.

Treatment with standard (U.S.) Cue-lure + Methyl eugenol (1:1) ratio in wafers showed two peak periods of fruit fly occurrence on cucurbits in Surkhet and other districts as compared to other treatments using soap water technology. Out of twelve treatments, (T7) soap water trap baited with standard (U.S.) Cue-lure in wafers among the sex and food lures attracted more fruit flies.

Drastic population reductions of fruit flies were observed on cucurbits by the use of poison traps in Banke and other districts. Occurrence of fruit flies was constantly reduced on cucurbits by the use of food lures, but mashed sweet gourd (MSG) was superior to protein hydrolysate (PH) in attracting adult fruit flies in Banke project district.

***Spodoptera litura* in tomato –** Sex pheromones from three sources for tobacco caterpillars were compared by conducting result demonstration in farmers' field. One *Spodo*-lure (U.S.) served as the standard, while the other lures from local markets (PCI and BIL) were used on two separate funnel traps. Five project districts, namely Rupendehi, Banke, Surkhet, Lalitpur, and Kaski, were considered for standardizing pheromones and traps.

Adult male moths of tobacco caterpillars were attracted more to sex pheromones from the U.S., followed by BIL and PCI (India) from local markets in the Banke project district, but U.S. lures were less attractive in Rupendehi.

***Helicoverpa armigera* in tomato –** Sex pheromones from four sources for tomato fruit worm were compared by conducting result demonstration in farmers' fields. One *Heli*-lure (U.S.) served as the standard, while the other lures from local market (NBC, PCI and BIL) were used on four separate funnel traps. Five project districts, namely Rupendehi, Banke, Surkhet, Lalitpur and Kaski, were considered for standardizing pheromones and traps.

Adult male moths of tomato fruit worm on the tomato crop were attracted more to sex pheromones from NBC (Nepal), followed by PCI and BIL (India) lures from the local market and the standard lure from (U.S.) in the Banke project district. Total male moths trapped by NBC *Heli*-lure (1,235) seem to be much higher than the cumulative figure of U.S., PCI, and BIL *Heli*-lures (151). NBC *Heli*-lure provides maximum effective period 2-3 times more, area coverage 10 times more (5,000m$^2$), and 10-12 times cheaper in terms of quality than the *Heli*-lures from U.S., PCI, and BIL, respectively.

**Eggplant shoot and fruit borer –** Sex pheromones from three sources for eggplant shoot and fruit borer were compared by conducting result demonstration in farmers' fields. One *Leucin*-lure (U.S.) served as the standard, while the other luersfrom local markets (PCI and BIL) were used on three separate water traps. Five project districts, namely Rupendehi, Banke, Surkhet, Lalitpur and Kaski, were considered for standardizing pheromones and traps.

Adult male moths of fruit and shoot borer of eggplant were attracted more tosex pheromones from PCI (India), followed by BIL (India) from local markets and the standard lure (U.S.) in the Rupendehi project district. The population of adult male moths of shoot and fruit borer of eggplant was drastically reduced on eggplant crop by the use of sex pheromones in the Rupendehi project district. The occurrence of a single peak during the fourth week of April offered opportunity for the management of the pest in the district utilizing an early warning system.

**Country: India**

**IPM package development for eggplant**

The effect of various IPM practices was studied against insect pests, diseases, and nematodes in Brinjal. These included various combinations of seed treatment with *Pseudomonas fluorescens* and soil application of neem cake as well as foliar spray of fish oil rosin soap and yellow sticky traps. Considering the incidence of insect pests, the maximum ESFB damage and mite incidence was observed on farmers' practice, while the minimum damage and incidence was observed in the IPM plots. Similar results were seen with diseases and nematodes.

**Technology transfer**

**Technology transfer of IPM practices in vegetable crops through NGO collaboration:** At present, four international NGOs, CARE-Bangladesh, Mennonite Central Committee (MCC), Action Aid-Bangladesh, and Practical Action-Bangladesh, are collaborating in disseminating IPM CRSP-BARI technologies in vegetable crops at the farm level. According to the agreement, IPM CRSP provides various technical support to the NGOs including training of NGO staff and technical information in implementing technologies at the field level. The NGOs, on the other hand, carry out the technology transfer activities in farmers' fields through their existing extension programs. Selected field officers of all the NGOs received theoretical and practical training on various technologies from IPM CRSP-BARI scientists. During 2007-2008, CARE-Bangladesh, Action Aid, and Practical Action took part in the collaboration through FoSHoL (Food Security for Sustainable Household Livelihoods) project, which is funded by the European Commission and coordinated by IRRI. MCC has been collaborating through its own extension programs.

**Technology transfer by CARE-Bangladesh**: CARE-Bangladesh conducted limited technology transfer activities in 2007-2008 due to displacement and shuffling of the field staff. Only a few demonstrations on soil amendment with poultry refuse and mustard oil-cake were established in the Rajshahi area.

**Technology transfer by MCC-Bangladesh**: MCC carried out demonstrations on five IPM technologies in farmers' fields at different sites and also arranged training programs for NGO staff and farmers.

1. Cultivation of grafted tomato: Demonstrations of grafted eggplant crop were established in farmers' fields in the districts of Bogra, Tangail, and Comilla in collaboration with three partner NGOs (PNGO). The average grafting success was as high as 98%. The farmers were very impressed with the performance of the grafted crops as compared to the non-grafted ones. Presently, the crops are at fruiting stage.

2. Fruit fly control in cucurbit crops by pheromone bait trapping: Pheromone bait trapping was adopted by 123 farmers in four sites of Comilla (Chandina), Sirajganj (Shahjadpur), and Bogra (Bogra sadar and Sariakandi) districts in bitter gourd, bottle gourd, snake gourd, sweet gourd, and pointed gourd crops. Farmers were highly satisfied with the results of pheromone bait trapping as the fruit damage was very low compared to that of the pesticide-treated fields. As a result, all the farmers obtained higher yields and more economic returns.

3. Demonstration of soil amendment practice with poultry refuse and mustard oil-cake: Four demonstrations with as many farmers were established at one site (Chandina) of the Comilla district in seedbeds as well as in the main field of cabbage and eggplant crops. As poultry refuse was not available in all the sites, the farmers used mustard oil-cake. Results of both the soil amendment materials effected less than 5% plant mortalities from diseases. The farmers were happy with the results as the crop stand was excellent with luxurious plant growth.

4. Demonstration of manual destruction of leaf-eating caterpillars in cabbage and cauliflower crops by hand picking: In collaboration with five partner NGOs, MCC established five demonstrations in five locations of three districts, Comilla, Bogra, and Dinajpur, involving 15 farmers in a total area of 1.5 acres. Farmers considered the practice laborious, but found it important and useful as pesticide use is hazardous to health.

5. Training of NGO staff and farmers: MCC trained 36 staff members (25 male & 11 female) of their 18 partner NGOs (PNGOs) on various IPM technologies during 2007-2008. In turn, the PNGO staff trained as many as 1,000 beneficiaries (all female) of 18 PNGOs for transferring IPM technologies.

**Technology Transfer by Practical Action-Bangladesh (PAB):** PAB established demonstrations on three IPM technologies in farmers' fields in the districts of Jamalpur, Madaripur, Faridpur, and Rajbari, and also carried out training programs for NGO staff and farmers.

1. Demonstrations of fruit fly control in cucurbit crops by using pheromone bait traps: The demonstrations were carried out in 18 villages in the districts of Jamalpur, Madaripur, Shariatpur, Faridpur and Rajbari. They involved 136 farmers (105 male & 31 female) on eight cucurbit crops in a total area of 8.75 ha. The technology was very effective in respect to fruit fly control, crop yield, and economic returns and the farmers were highly impressed. Pheromone bait trapping decreased fruit fly damage by 48.1% over farmers' practice of pesticide applications. As a result, yields of different cucurbit crops in IPM fields were 30 to 108% higher than that of the non-IPM fields, and the farmers received 36 to 138% higher economic returns.

2. Demonstrations of soil amendment practices with mustard oil-cake (MOC): The use of MOC was demonstrated in 5ha of seedbeds of eggplant, tomato, cauliflower, cabbage and chili in 31 villages of the districts of Jamalpur, Madaripur and Rajbari. They involved 172 farmers (122 male & 50 female). Soil amendment practice decreased seedling mortalities, reduced seedling production cost by 10%, and increased net income by 72% over farmers' practice.

3. Demonstrations of cultivation of grafted eggplant and tomato: The practice was demonstrated in four villages of the districts of Jamalpur, Madaripur, and Rajbari. They involved four farmers. The farmers raised several thousand grafted seedlings and sold them to interested farmers at Taka 5/= per seedling that fetched them 100% profit. The farmers are continuing the grafting practice.

4. Demonstrations for eggplant FSB control by using sex pheromone bait trap: Demonstrations were established in two villages of the Jamalpur district involving 32 farmers in an area of 2.75ha of eggplant. The farmers were impressed with the effectiveness of the technology and saved on pest control costs by 75% (Taka 12,975/= per ha).

5. Training of NGO staff and farmers: Practical Action trained 10 field staff members (8 male & 2 female) and as many as 629 farmers (228 male & 401 female) on different IPM technologies.

**Technology transfer by Action Aid-Bangladesh (AAB)**: AAB disseminated only the pheromone bait trapping for fruit fly control and carried out training programs for farmers.

1. Demonstration of fruit fly control by pheromone bait trapping and MSG trap: AAB established demonstrations in 86 farmers' fields in four districts (Khulna, Satkhira, Ptuakhal,i and Kurigram) to transfer the IPM practice of bait trapping with 'cuelure' pheromone and MSG. The demonstrations were carried out on seven kinds of cucumber crops involving 80 farm families. Fruit fly damage was 33% lower in bait trapping fields than in pesticide-treated fields. As a result, farmers practicing the IPM method harvested twice as much as the non-IPM farmers who resorted to frequent pesticide use.

2. Training program for NGO staff: During 2007-2008, AAB trained 300 (210 male & 90 female) farmers for transferring various IPM technologies for vegetable cultivation.

**Transfer of IPM CRSP-BARI technologies and testing of promising IPM programs through the adjunct PL 480 project "Facilitating the Development and Spread of IPM CRSP"**

This USAID-funded (PL480-416B excess/residue fund) project entitled "Facilitating the development and spread of IPM CRSP" is coordinated by the Bangladesh Agricultural Research Council (BARC) and implemented by the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE). The three-year project, which ended in December 2008, includes three programs: (a) Transfer of vegetable IPM technologies, (b) Testing of promising research programs in wider areas of the country; and (c) Training of DAE officers and target farmers.

**Transfer of vegetable IPM technologies**: The following six technologies were demonstrated in farmers' fields in 14 upazilas (sub-districts) of the districts of Dhaka, Jessore, Comilla, and Bogra: (a) Cultivation of grafted eggplant for controlling bacterial wilt (BW) disease; (b) Use of resistant eggplant variety for controlling fruit & shoot borer (FSB), jassid, and BW; (c) Sex pheromone-based management of eggplant FSB; (d) Integrated approach for the management of FSB, BW, and soil-borne disease pathogens; (e) Use of IPM package for fruit fly control in cucurbit crops; and (f) Integrated management of insect pests and soil-borne pathogens in cabbage and cauliflower.

**(a) Cultivation of grafted eggplant for controlling bacterial wilt (BW) disease**: Demonstrations and dissemination of the cultivation of grafted eggplant were established in farmers' fields in one upazila (Bagherpara) of the Jessore district, three upazilas (Bogra sadar, Shahjahanpur, & Shibpur) of the Bogra district, and one upazila (Belabo) of the Narsingdi district. The area of demonstration fields in three districts totaled 1.5ha. Results of the grafted eggplant crops were highly encouraging with respect to effective control of BW disease and higher yields. Plant mortalities in grafted fields ranged from 2 to 3.5% as compared 7 to 20.6% in non-grafted fields. As a result of better crop establishment, grafted fields produced 3t/ha to 20.8t/ha higher yields.

**(b) Use of resistant eggplant variety for controlling fruit & shoot borer (FSB), jassid, and BW:** Demonstrations were carried out with two pest-resistant eggplant varieties in one upazila (Bagherpara) of the Jessore district and three upazilas (Bogra sadar, Shepur & Shibganj) of the Bogra district. Demonstrations of variety BARI Begun-6, which is resistant to FSB, jassid, and BW, were established in Jessore, and BL-114 (resistant to BW& FSB) in Bogra in a total area of 1.2ha. The performances of the resistant varieties were excellent except for the yield in Jessore, probably because of poor crop management. In Jessore, plant mortality of the local variety was 9.5% as compared to 5.7% on the resistant variety, BARI Begun-6. Fruit infestation in the resistant variety was 28.6% as compared to 37.5% on the local one. The results of both the resistant varieties in Bogra were very promising. Plant mortalities of the resistant varieties were 1.8 to 2.2% as compared to 10.9% of the local one. Similarly, fruit infestations by FSB were 17.1 to 31.5% against 53.5% on the local one, a result of low pest infestations, the resistant varieties produced 4t/ha to 6.4t/ha increased yields.

**c) Sex pheromone-based management of eggplant FSB:** Sex pheromone-based IPM practice consisting of (a) sanitation (manual destruction of infested twigs and fruits), (b) use of pheromone bait trapping; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 800-1,000 adults per ha) were demonstrated and disseminated in a total area of 160.5ha in four upazilas (Jessore sadar, Monirampur, Bagherpara, & Chougacha) of the Jessore district, three upazilas (Bogra sadar, Shibganj, & Sherpur) of the Bogra district, three upazilas (Chandina, Debidwar, & Burichang) of the Comilla district, and three upazilas (Belabo, Raipura, & Monohardi) of the Narsingdi district. The demonstrations were carried out in both the winter and summer seasons.

The performance of the IPM package was highly successful in all the districts. In Jessore, FSB infestations were 27 and 44% lower in winter season and 42 and 43% lower in the summer season in the IPM fields. As a result, the IPM fields produced 7.9t/ha higher yields in the winter season and 10.8t/ha higher in the summer season. Similar results were obtained in Bogra, Comilla, and Narsingdi. IPM fields suffered 32 to 69% lower infestations of FSB in the two seasons and produced 3.4t/ha to14.1t/ha higher yields.

**(d) IPM package for the management of FSB, BW, and soil-borne disease pathogens in eggplant**: IPM package consisting of (a) soil incorporation of decomposed poultry refuse; (b) bait trapping with sex pheromone; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 800-1,000 adults per ha) were demonstrated and disseminated in a total area of 3.75ha in four upazilas (Jessore sadar, Monirampur, Bagherpara & Chougacha) in the Jessore district, three upazilas (Bogra sadar, Shibganj & Sherpur) in the Bogra district, three upazilas (Chandina, Debidwar & Burichang) in the Comilla district, and three upazilas (Belabo, Raipura & Monohardi) in the Narsingdi district. The demonstrations were carried out in the winter and summer seasons.

The performance of the IPM package was highly successful and impressive in all the districts. The eggplant crops in IPM fields suffered 1.6 to 5.5% plant mortalities and 9.8 to 20.4% fruit infestations of FSB compared to 5.5%= to 15.2% plant mortalities and 18.6 to 42.2% FSB infestations in the non-IPM fields. As a result, the IPM fields produced 2.5t/ha to 26.1t/ha increased yield.

**(e) Use of IPM package for fruit fly control in cucurbit crops:** An IPM package, developed for controlling cucurbit fruit fly, fruit borers, and other pest insects was demonstrated and disseminated in a total area of 225ha in four upazilas (Jessore sadar, Monirampur, Bagherpara & Chougacha) in the district Jessore district, three upazilas (Bogra sadar, Shibganj & Sherpur) in the Bogra district, three upazilas (Chandina, Debidwar & Burichang) in the Comilla district, and three upazilas (Belabo, Raipura & Monohardi) in the Narsingdi district. The IPM package consisted of (a) sanitation (manual destruction of infested fruits); (b) bait trapping with cuelure pheromone; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 800-1,000 adults per ha). The demonstrations were carried out in the winter and summer seasons.

The performance of the IPM package was highly effective in all the districts in controlling the pests and producing higher yields. Average fruit infestations of different crops in different districts ranged from 4.2 to 9.5% in IPM fields compared to 13.4 to 23.5% in non-IPM ones. As a result, IPM fields produced 4.1t/ha to 6.4t/ha increased yields.

**(f) Integrated management of insect pests and soil-borne pathogens in cabbage and cauliflower:** The diamond back moth (DBM), *Spodoptera xylostella*, and armyworm, *Spodoptera litura*, are the two most damaging leaf pest insects of cabbage and cauliflower in Bangladesh. In addition, a number of soil-borne diseases and root-knot nematodes cause serious damage to the crops. An IPM package, developed to control these pest insects and diseases, was demonstrated in one upazila each of the Jessore (Jessore sadar), Bogra (Bogra sadar), Comilla (Chandina) and Narsingdi (Belabo) districts. The IPM package consisted of (a) soil incorporation of decomposed poultry refuse at the rate of 3t/ha; (b) manual destruction of leaf-eating caterpillars; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 800-1,000 adults per ha).

Performance of the IPM package was highly effective at all the sites. Pest infestations in IPM fields of different sites ranged from 2.1 to 3.2% compared to 6.5 to 9.8% in non-IPM fields. As a result of very low pest infestations, the IPM fields produced 15.8t/ha to 21.9t/ha higher yields in cabbage.

**Tests of promising IPM research programs in wider areas:** The following research activities were carried out at BARI farms at Gazipur and Jessore and in farmers' fields in Jessore, Bogra, and Comilla.

**(a) Field evaluation of IPM package for controlling fruit and shoot borer (FSB) in eggplant crop**: The IPM package consisted of (a) sanitation (manual destruction of infested twigs and fruits); (b) bait trapping with sex pheromone; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 1,000-1200 adults per ha). The performance of the IPM package was compared with farmers' practice (non-IPM) of pesticide sprays every three-four days during the winter and every day during the summer seasons. The trials were conducted in farmers' fields in four villages of the Jessore district during the winter and summer seasons.

The results were highly effective at all the locations, producing significantly lower pest infestations and higher yields. In IPM fields, FSB infestations ranged from 1.8 to 9.9% in shoots compared to 8.8 to 32.6% in non-IPM and 5.5 to 18.7% in fruits compared to 23.9 to 58.9% in non-IPM fields in different locations. As a result, the IPM fields produced 8.6t/ha to 14.5t/ha increased yields. Moreover, pest costs were 2.4 to 4 times less in IPM fields.

**(b) Field evaluation of IPM package for management of fruit and bore complex in bitter gourd crop**: The cucurbit fruit fly (*Bactrocera cucurbitae*) is the most damaging pest insect of cucurbit crops, including bitter gourd in Bangladesh. Recently, three fruit boring pest insects (*Spodoptera litura*, *Spodoptera exigua*, pumpkin caterpillar) have appeared to be highly damaging in many areas. Therefore, an IPM package was developed consisting of (a) sanitation (manual destruction of infested fruits); (b) bait trapping with cuelure pheromone; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 100-1,200 adults per ha). The IPM package was evaluated for two seasons in Nangorpur village of the Jessore district to assess and compare its effectiveness with farmers' practice (non-IPM) of pesticide applications every 3-4 days. The experiment was laid out in RCB design with three replications. Data were recorded on pest infestations, pest control costs, and crop yield.

The results of the IPM package were highly encouraging and effective for both seasons in controlling the pests and producing higher yields. In both the years of 2007 and 2008, *Spodoptera litura* was the dominant pest, followed by *S. exigua* (Table 1). Fruit fly infestations were 15.3 to 18.3 times lower in IPM fields than that of the non-IPM ones in both the years. Similarly, fruit borer infestations were 14.5 to 16.6 times lower in IPM fields. As a result, the IPM fields produced 1.4 to 1.6 times higher yields. Moreover, the cost of pest control was 2.7 times less in IPM practice than that of the non-IPM one.

**c) Determination of parasitism efficiency of the larval parasitoid, *Trathala flavoorbitalis*, on eggplant fruit and shoot borer (FSB)-resistant eggplant varieties**: The larval parasitoid, *Trathala flavoorbitalis*, is a highly efficient larval parasitoid of FSB and is widely available in eggplant fields. Trials were conducted to determine its parasitizing efficiency in fields grown with pest-resistant eggplant varieties. FSB-infested eggplant twigs and fruits were collected from the field planted with FSB-resistant eggplant varieties (BARI Begun-6, BARI Begun-7, & BL-114) and a susceptible variety (Jessore local), and the FSB larvae recovered from the infested twigs and fruits were reared in the greenhouse to record the emerging adults of FSB and the parasitoid. Shoot infestations ranged from 8.7 to 24.7% in the susceptible variety and 4.6 to 13% in different resistant varieties. Similarly, fruit infestations ranged 21.7 to 43.3% in the susceptible variety compared to 17.2 to 37.4% in the resistant varieties. Parasitism rates of FSB were higher on the susceptible variety, ranging from about 24 to 49.5% compared to about 5%to 38%.

**(d) Affect of insecticide sprays on the abundance of the FSB larval parasitoid, *Trathala flavoorbitalis***: Indiscriminate use of pesticides in eggplant crops by farmers has almost wiped out the populations of various natural enemies including the parasitoids. To determine how destructive the farmers' practice of relying solely on pesticide use for pest control was, a study was conducted at BARI farm, Gazipur to compare pesticide sprays at different frequencies using the following treatments: (a) $T_1$= No spray; (b) $T_2$= Spray at 15-day intervals; (c) $T_3$= Spray at 7-seven day intervals; and (d) $T_4$= Spray every day. FSB-infested twigs of eggplant were collected to recover the larvae and rear them to record the emergence of the adults of FSB and the parasitoid. Results, as expected, showed that insecticide applications seriously affected the population of the parasitoid. Daily applications of pesticides completely wiped out the parasitoid population from the eggplant crop and as a result there was no parasitism of FSB larvae. Parasitism rates of FSB larvae ranged from 0-5% and 4.5-11%, respectively, in the fields that received pesticide applications every seven days and 15 days. On the other hand, parasitism rates were 15-28% in the fields receiving no pesticide applications. Results, therefore, confirm that the farmers' practice of indiscriminate pesticide application is highly detrimental to the populations of natural enemies.

**(e) Performance of virus-resistant tomato lines under open field cultivation**: Field trials were conducted at the BARI farms, Gazipur and Jessore and in farmers' fields in the Bogra district to evaluate the performance of four exotic tomato lines (TLB-111, TLB-130, TLB-133, & TLB-182) against the tomato yellow curl virus (TYCV) disease and to compare the four lines with two BARI varieties (BARI Tomato-2 & BARI Tomato-10). Results showed that the exotic lines were highly tolerant/resistant to the virus disease and as a result they produced higher yields. Among the exotic lines, TLB-130 and TLB-133 were more promising with respect to virus resistance, but TLB-182 was the top yielder. Development of virus-resistant tomato varieties will be a significant breakthrough in tomato varietal improvement that will increase yields and farmers' income and reduce pesticide use.

**(f) Performance of grafted summer tomato hybrids for bacterial wilt (BW) disease control**: The grafting technique of tomato varieties for winter season cultivation is already popular among the farmers. In order to assess the performance of grafted summer tomato hybrids at the farm level, trials were conducted at BARI farm, Gazipur during the 2008 summer season. BARI Hybrid Tomato-3 and BARI Hybrid Tomato-4 (scions) were grafted on the wild eggplant (*Solanum sisymbriifolium*) rootstock in June and the grafted plants were transplanted in July. Data were recorded on plant mortality, yield contributing characters, virus infection, and yield. Performance of the grafted summer tomato hybrids was highly encouraging and effective in reducing plant mortality, increasing fruit bearing, and producing higher yield. Grafted summer tomato plants suffered no plant mortality from bacterial wilt (BW) disease as compared to 21 to 33% mortality in non-grafted plants. As a result, grafted plants produced 1.2 to 1.9 times higher yield.

**(g) Effectiveness of soil amendments and bio-control agents for the management of insect pests and diseases**: Every year, cabbage crops are seriously damaged by various soil-borne diseases and leaf-eating pest insects. An IPM package consisting of (a) sanitation (manual destruction of leaf-eating caterpillars by hand-picking); (b) soil incorporation of decomposed poultry at the rate of 3t/ha; and (c) weekly mass-release of egg parasitoid, *Trichogamma evanescens* (at the rate of one gm parasitized eggs per ha), and larval parasitoid, *Bracon habetor* (at the rate of 100-1,200 adults per ha) was evaluated at BARI farms at Gazipur and Jessore and farmers' fields in Jessore and Comilla. The performance of the IPM package was compared with farmers' practice of soil incorporation with cowdung.

The performance of the IPM package was highly effective at all the locations. Plant mortality due to diseases ranged from 1.5 to 3.9% in IPM practice compared to 14 to 17% in farmers' practice. Similarly, IPM fields suffered only 0 to 2.3% pest infestations compared to 3.3 to 3.5% in farmers' practice. As a result, the IPM fields produced 1.2 to 1.4 times increased yield.

**(h) Integrated management of nematode-fungal complex in pointed gourd**: Palwal or pointed gourd (*Trichosanthes dioica*) is a popular and exportable vegetable of Bangladesh. Its production is seriously constrained due to the attacks of various soil-borne pathogens and root-knot nematode. Three organic soil amendment practices, (a) soil incorporation of decomposed poultry refuse at the rate of 5t/ha; (b) soil incorporation of mustard oil-cake at the rate of 300Kg/ha; and (d) soil incorporation of bio-control agent *Trichoderma harzianum* at the rate of 50g/pit (cultured with barley), were evaluated to assess their effectiveness in protecting the cabbage crops from the attack of pests. The treatments were compared with farmers' practice of soil incorporation of decomposed cowdung at the rate of 5t/ha. The trials were conducted at BARI RARS farm at Jessore for two years and for one year in farmers' fields in Shahabajpur village of Jessore.

Results of the trials conducted at RARS farm at Jessore showed that the organic soil amendments effectively controlled the populations of root-knot nematode (RKN) and *Fusarium* sp., producing higher yields than that of the untreated control. In the second year, the effects of the organic amendments still suppressed the populations of the soil-borne pathogens and RKN, which increased significantly in the untreated control. The results of the trial conducted in the farmers' fields were similar to that of the one conducted at RARS farm at Jessore.

**Extension agent and target farmer training program**

Training programs were arranged for the field level extension officers of DAE and the target farmers in order to disseminate the IPM technologies successfully and rapidly among the vegetable producers. BARI scientists associated with the IPM CRSP project acted as trainers. During 2007-2008, as many as 630 field officers and farmers of different sites were trained on IPM technologies.

**Farmer field days**

Three field days were conducted in 2008, one each in Debidwar of Comilla (May 8), Shekerkhola of Bogra (May 25), and Nangorpur of Jessore (June 28). Total attendance for each field day was more than 300 people, including farmers, extension workers, research personnel, local leaders, and government officials. The field days were presided over by executives of agricultural ministry.

**Enterprise development**

The IPM technologies developed through IPM CRSP-BARI programs for vegetable crops have been highly effective and economically profitable at the farm level. As a result, large numbers of farmers within and outside the project sites have successfully adopted the IPM practices, resulting in demand of several inputs such as grafting clip, seedlings of grafted eggplant and tomato, traps (plastic container) and lure dispenser for pheromone baiting, and various bio-control agents (parasitoids and predators).

**(a) Plastic clips for eggplant and tomato grafting**: Small plastic clips that were needed to hold the grafted plant in place for graft union were unavailable in Bangladesh. Recognizing the success and demand of plastic clips at the farm level, one small private firm, "Shapla Enterprise" (proprietor Mr. Saiful Islam), started to manufacture and supply the clips to the users. Starting from 2004, "Shapla Enterprise" has supplied as many as 250,000 clips to different organizations and farmers.

**(b) Production of grafted seedlings of eggplant and tomato**: Cultivation of grafted eggplant and tomato crops has created a great impact on the farming community in different areas of the country because of its effectiveness in solving the field problems as well as bringing about two-three fold economic returns. More and more farmers in the problematic areas are adopting this technique, resulting in high demand for grafted seedlings. Nurserymen as well as individual farmers have now started producing grafted seedlings of eggplant and tomato on a commercial scale to sell to the interested farmers. In 2008, Mr. Amjad Hossain of Shahjahanpur Upazila in the Bogra district (proprietor of Akhi Nursery & Seed Store) earned about 200% profit by producing 24,000 grafted eggplant seedlings. In Komolganj Upazila of the Moulvibazar district, a farmer, Mr. Gazi Mainuddin, raised 7,000 grafted seedlings of summer tomato in 2008 and earned twice as much the production cost. Demand for grafted eggplant and tomato crops is increasing every year and the grafting enterprise is expected to flourish rapidly in future.

**Production of traps (plastic containers) and lure dispensers for pheromone baiting**: The performance of pheromone baiting for the control of cucurbit fruit fly and eggplant FSB has created an extraordinary impact among the farming communities in most of the intensive vegetable growing areas of the country. Thousands of farmers have adopted this technology to protect their crops. As a result, there is high demand for the synthetic sex pheromones as well as the plastic traps (transparent plastic containers with pheromone dispensers) among the farmers. A private firm, "Safe Agriculture Bangladesh Limited (SABL)," has started production and marketing of plastic containers and pheromone dispensers in plastic/rubber tubing at a reasonable price. In 2008, SABL sold out about 6,000 pheromone lures (cuelure) that can cover about 100 ha at a time for fruit fly control in cucurbit crops.

**(a) Production and marketing of bio-control agents (parasitoids and predators)**: Farmers' current practice of indiscriminate use of pesticides has resulted in complete destruction of natural enemies (parasitoids and predators) of various vegetable pests in the field. As a result, natural biological control system has become ineffective. Results of a series of IPM CRSP-BARI on-farm trials carried out in different project areas have convinced the farmers to avoid pesticide use in order to exploit the benefits of biological control. To supplement and augment the natural populations of different bio-control agents, mass-release of some efficient egg and larval parasitoids and predators is necessary. Safe Agriculture Bangladesh Limited (SABL) is presently producing and marketing four species of *Trichogramma* egg parasitoids, one species of larval parasitoid (*Bracon habetor*), and green lacewing predator. These natural enemies are highly effective in controlling various pest insects in cucurbit and eggplant crops. Release of these bio-control agents costs only Tk. 400-700 per ha per crop season (U$6-10/ha). In 2008, SABL distributed about 3,000g of egg parasitoids and 3,000 bunkers of larval parasitoid that can be applied to 800-1,000ha of crop land.

The development of the above enterprises has opened up opportunities for local as well as urban businessmen to earn money through the development of IPM technologies. There is, however, potential for the rural people to start cottage industries with other IPM inputs, such as establishing small poultry farms and trading of poultry refuse which is highly effective for soil amendment practice.

**Country: Nepal**
**Technology transfer in Nepal**

Proven technologies such as pheromone traps, bio-pesticides, bio-fertilizers, and grafted seedlings were demonstrated in farmers' fields and the results are encouraging to researchers, development organizations, service providers, and innovative leader farmers. The result of pheromones and grafting technology is expanding in Nepal. This will not only benefit the poor farmers but also reduce the use of pesticides that cause hazards to health, environment, and the biodiversity of our agro-ecosystem. However, bio-pesticides and bio-fertilizers require further field testing to generate basic information before environment friendly technology is transferred to farmers.

With respect to grafting, three scientists of NARC imported graft technology from Bangladesh with the support from IPM CRSP/WI. The technology was successfully transferred to two project districts:

Kaski and Lalitpur. Twelve nurserymen out of 20 participants actively participated during two days (June 2-3, 2008) of training organized by NARC/IPMCRSP/WI at the Plant Pathology Division, Khumaltar.

**Country: India**

Through TERI, demonstrations of IPM practices were made on vegetable crops in farmers' fields in five villages in UP, five villages in AP, and four villages in Karnataka. Thousands of farmers were targeted including women. Thirty group meetings were held, several field days were organized, and training on safe use of pesticides held. The crops were eggplant, tomato, Okra, and cucurbits. IPM demonstration plots have been added at seven sites in U.P. The treatments were (1) Seed treatment with *Trichoderma* (controls *Fusarium, Pythium)* and *Pseudomonas* (controls bacterial pathogens), (2) neem cake (controls nematodes, *Agrotis* sp.), (3) Pheromones (controls *Bactrocera cucurbitae)*, and (4) Bt (controls Coleoptera, small lepidopteran larvae etc.). Farmers are receiving a 50% increase for their vegetables because of the high quality, lack of borer damage, and the low amounts of pesticides used.

Training on grafting was also held. Both TNAU and TERI participated with training of farmers in May 2008 in grafting technology for management of wilts, root knot nematodes, and tolerance to flooding. The training was provided by the IPM CRSP in collaboration with AVRDC-The World Vegetable Center.

**Dissemination and impact assessment of IPM technologies**

Alamgir Hossain, M. A. Matin, (BARI), A. N. M. R. Karim (IPM CRSP/Virginia Tech) and George W. Norton (Virginia Tech)

A study was carried out in four intensive vegetable growing districts of Comilla, Narsingdi, Jessore, and Bogra to investigate the dissemination of IPM technologies, such as the use of bait trapping with 'cuelure' pheromone for controlling fruit fly in bitter gourd crop and use of soil amendment with poultry refuse or mustard oil-cake for controlling soil-borne diseases, and assess the impacts of the technologies. The total number of IPM farmers was 130 (95 for pheromone bait trapping, 35 for soil amendment with poultry refuse/mustard oil-cake). The non-IPM farmers who have been using pesticides for pest control totaled 120 and they were selected from the neighboring villages. Data were collected on crop establishment, crop yields, input-output costs, price, farmers' perception of technologies, and their impacts by using pre-designed interview schedules from April to August 2008. 'Perceived Impact Score (PIS)' was used to highlight the overall impact of the technologies. PIS was computed for each changed item by summing up the weights for responses of all the sample farmers against that of the changed item. The assigned weights were 3, 2, 1, and 0; 3 for excellent, 2 for moderate, 1 for average, and 0 for no change, respectively. In order to make a meaningful comparison of data, the PIS for a particular changed item was standardized by using the following formula:

Standard PIS = (Observed perceived score ÷ Possible perceived score) x 100

Results showed that the impact of IPM technologies on crop yield, economic returns, gross margin, and total variable cost was positive. The IPM adopters received higher economic benefits as compared to the non-IPM farmers although their investment was much higher for crop production. The average yields in IPM fields adopting pheromone bait trapping and soil amendments with poultry refuse or mustard oil-cake were 18% and 13% higher, respectively, than that of the non-IPM fields. Similarly, the gross returns for pheromone baiting and soil amendment were 44% and 34% higher, respectively, over the non-IPM adopters who resorted to pesticide use. As a result, the IPM adopters received higher economic returns, having an average benefit-cost ratio of 3.02 as compared to 2.26 of the non-IPM farmers.

The socio-economic impacts as measured by using PIS show that the overall standard PIS (SPIS) of twelve different indicators was 51, indicating a positive overall change in socio-economic status of the farmers who adopted IPM practices. The highest observed SPIS was 74 for social status, and the lowest 28 for capability of taking lease of land for poultry/fish culture (Table 1).

It was obvious from the surveys that the IPM adopters were highly impressed with the effectiveness of the IPM practices in solving the problems of crop losses from pest infestations. By adopting the IPM technologies they not only obtained higher crop yields and economic returns, but they were also benefited in various social and economic aspects.

Table 1. Socio-economic impacts of IPM practices as measured by 'Perceived Impacts Score (PIS)' technique, 2008.

| **Item (N=130)** | **PIS** | **Standard PIS** |
|---|---|---|
| Elevated social status | 290 | 74 |
| Better health condition | 275 | 70 |
| Access to better food | 230 | 59 |
| Improvement of environment | 240 | 62 |
| Improved sanitation | 210 | 54 |
| Improved livelihood | 170 | 44 |
| Improved communication | 180 | 46 |
| Access to recreational facilities | 170 | 44 |
| Access to better education | 130 | 33 |
| Capability to purchase agricultural equipment | 140 | 36 |
| Capability of taking lease of land for poultry/fish culture | 120 | 28 |
| Access to obtaining bank credits | 130 | 33 |

# Ecologically-Based Participatory IPM for Southeast Asia

*Michael Hammig, Clemson University*

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**Host Countries:** Indonesia, Philippines
**Collaborators:** Bogor Agricultural University, Sam Ratulongi University, FIELD, Indonesia, PhilRice, University of the Philippines at Los Banos, IRRI, Philippines

**IPM in cabbage in W. Java**
Comparing benefit to cost ratios for farmer practice compared to IPM was 1.32 to 2.73. IPM practices included dipping seedlings into locally-made fertilizer with *Trichoderma* and *Pseudomonas* plus the use of botanical insecticides along with hand-picking lepidopteran larvae.

**IPM in cabbage in N. Sulawesi**
A strain of *Trichoderma* was isolated locally and applied by mixing it with organic fertilizer. The local strain significantly decreased the incidence of *Fusarium* wilt in cabbage.

Biological control of cabbage caterpillars uses a local strain of *Metarizium*. A fungal pathogen of insects, *Metarizium,* was found on the cabbage-head caterpillar, *Crocidolomia,* and isolated. The insect pathogen was found to infect both *Crocidolomia* and the diamondback moth, *Plutella xylsotella*. This could be a useful biological control tool for use in future IPM activities.

A group of farmer leaders (7 women and 10 men) participated in farmer leader training in N. Sulawesi to learn the skills required to produce the SeMNPV of the beet armyworm. In addition, farmer leaders were trained on production techniques for *Trichoderma*.

**Degradable plastic sleeves for control of the cocoa pod borer in N. and S. Sulawesi**
In both N. and S. Sulawesi, the use of degradable plastic sleeves demonstrated that infestation by the pod borer is controlled using this approach. Preliminary evidence from S. Sulawesi suggests that infection by pod rot disease is also lower in the sleeved pods probably because they prevent fungal spores from landing on the pods.

**IPM in citrus in the Karo district of N. Sumatra**
IPM practices in citrus include pruning, sanitation (particularly removal of fallen, infested fruit), and use of several botanical insecticides. IPM practices eliminated insecticides and provided good pest control.

**IPM in chilli, cabbage, and Chinese cabbage in W. Sumatra**
Extracts of *Melia azadiracta* were tested against insect pests of chilli, cabbage, and Chinese cabbage in W. Sumatra. The plant extract successfully controlled thrips, leafhoppers (*Empoasca*), *Plutella*, and *Crocidolomia.* Follow-on field training was extended to 13 villages in N. Sumatra.

**IPM demonstration area: Techno-demo Central Experiment Station, Los Banos, Philippines**
The Techno-Demo Central Experiment Station, located on the campus of the University of the Philippines, Los Baños, provides an excellent venue for working with farmers and farmer groups to demonstrate IPM tactics and strategies. All pests (insects, plant pathogens, and weeds) are managed in ways to compare IPM with normal farmer practices. IPM tactics include grafting (for diseases and water-logging), VAM to reduce bacterial wilt and other disease, and stale seedbed technique for weed control. Insects (particularly the eggplant shoot and fruit borer) are managed by releases of *Trichogramma* and earwigs. IPM treated plots had higher yields with fewer chemical inputs.

**IPM in eggplant in Calauan, Laguna, Philippines**

IPM practices involved 1.) grafting eggplant onto resistant (EG 203) rootstock; 2.) VAM; 3.) releasing predatory earwigs; and 4.) *Trichogramma*. In addition, weeds were managed using the stale seedbed technique, which played a major role in producing higher marketable yields in fields where IPM practices were employed.

**Bogor Agricultural University**
**West Java, Indonesia**

**Cabbage IPM**

The study was conducted in a farmer's field (Pak Jaju) in plots of 500 m2 which included farmer practice and IPM practice. The IPM package consisted of mixing *Trichoderma* with bokashi, dipping seedlings in *Bacillus subtilis* and *Pseudomonas flourescence*, lowering the rate of synthetic fertilizers, hand-picking insect larvae, and using botanical insecticides for the control of lepidopteran pests. The results showed that IPM practices provided higher income for the farmer (Table 1).

**Broccoli IPM**

The study was conducted by four farmer collaborators (Pak Jupri, Pak Hamdan, Pak Ayep, and Pak Ujang) independently, each with plots of 500 $m^2$ which included normal farmer practice compared with IPM. The IPM package consisted of mixing *Trichoderma* with bokashi, dipping seedlings in *Bacillus subtilis* and *Pseudomonas flourescence*, lowering the rates of synthetic fertilizers, hand-picking insects, and using botanical insecticide for the control of lepidopteran pests. The results showed that IPM practice gave a higher net income (Tables 2-5).

**Green Onion IPM**

The study was conducted in a farmer's collaborator (Pak Ujang Dayat) in a plot of 500 m2 which included farmer practice and IPM practice. The IPM package consisted of mixing *Trichoderma* with bokashi, dipping seedlings in *Bacillus subtilis* and *Pseudomonas flourescence*, lowering the rates of synthetic fertilizers, hand-picking beet armyworm larvae, and using botanical insecticides for the control of lepidopteran pests. Laundry detergent was used to control black aphids. A yellow cloth coated with glue was used to control leafminers. The results of this field trial revealed that IPM practice lowered income as a result of low yield (Table 6). As with the broccoli trial (Table 5), no synthetic fertilizers were used. It is understood that IPM still requires synthetic fertilizer but at lower rates.

**Survey of insect pests and diseases of Cucumber**

Insects found attacking cucumbers were *Aphis gossypii*, *Liriomyza huidobrensis*, *Thrips parvispinus*, *Trialeurodes vaporariorum*, *Aulocophora* sp., *Diaphania indica*, and *Leptoglossus australis*. According to farmers, the most important insect pests were aphids and leafminers. Two major parasitoids of *Liriomyza huidobrensis* were *Opius chromatomyiae* and *Hemiptarsenus varicornis* (Table 7).

Table 1. Budget analysis of IPM and Farmer Practice (Crop: Cabbage; Farmer: Pak Jaju)

| Items | IPM | Farmer |
|---|---|---|
| Yield (kg) | 685 | 300 |
| Price (Rp.) | 2,000 | 2,000 |
| Gross Income | 1,370,000 | 600,000 |
| Material Costs | | |
| Seeds | 56,000 | 56,000 |
| Fertilizers + Lime | 136,000 | 146,000 |
| Animal Manures | | 100,000 |
| Bokashi | 115,500 | |
| Pesticides | - | 32,500 |
| Service Costs | | |
| Land preparation and cultivation | 120,000 | 120,000 |
| Preparation of bokashi, botanical pesticide, biotic agents | 75,000 | - |
| Total Costs | 502,500 | 454,500 |
| Net Income | 867,500 | 145,500 |
| B/C Ratio | 2,73 | 1,32 |

Table 2. Budget analysis of IPM and Farmer Practice (Crop: Broccoli; Farmer: Pak Jupri)

| Items | IPM | Farmer |
|---|---|---|
| Yield (kg) | 343 | 321 |
| Price (Rp.) | 4,000 | 4,000 |
| Gross Income | 1,372,000 | 1,284,000 |
| Material Costs | | |
| Seeds | 60,000 | 60,000 |
| Fertilizers + Lime | 158,000 | 217,500 |
| Animal Manures | - | 100,000 |
| Bokashi | 115,500 | - |
| Pesticides | - | 102,500 |
| Service Costs | | |
| Land preparation and cultivation | 180,000 | 180,000 |
| Preparation of bokashi, botanical pesticide, biotic agents | 75,000 | |
| Total Costs | 588,500 | 660,000 |
| Net Income | 783,500 | 624,000 |
| B/C Ratio | 2.33 | 1.94 |

Table 3. Budget analysis of IPM and Farmer Practice (Crop: Broccoli; Farmer: Pak Hamdan)

| **Items** | **IPM** | **Farmer** |
|---|---|---|
| Yield (kg) | 209.2 | 195.8 |
| Price (Rp) | 3,500 | 3,500 |
| Gross Income | 732,200 | 685,300 |
| Material Costs | | |
| Seeds | 60,000 | 60,000 |
| Fertilizers + Lime | 95,000 | 207,500 |
| Animal Manures | | 200,000 |
| Bokashi | 115,500 | |
| Pesticides | | 108,000 |
| Service Costs | | |
| Land preparation and cultivation | 150,000 | 150,000 |
| Preparation of bokashi, botanical pesticide, biotic agents | 75,000 | - |
| Total Costs | 495,500 | 725,500 |
| Net Income | 236,700 | -40,200 |
| B/C Ratio | 1.48 | 0.94 |

Table 4. Budget analysis of IPM and Farmer Practice (Crop: Broccoli; Farmer: Pak Ayep Hidayat)

| **Items** | **IPM** | **Farmer** |
|---|---|---|
| Yield (kg) | 570.5 | 548 |
| Price (Rp.) | 2,500 | 2,500 |
| Gross Income | 1,426,250 | 1,370,000 |
| Material Costs | | |
| Seeds | 60,000 | 60,000 |
| Fertilizers + Lime | 76,500 | 156,000 |
| Animal Manures | | 200,000 |
| Bokashi | 115,500 | |
| Pesticides | | 168,000 |
| Service Costs | | |
| Land preparation and cultivation | 180,000 | 180,000 |
| Preparation of bokashi, botanical pesticide, biotic agents | 75,000 | |
| Total Costs | 507,000 | 764,000 |
| Net Income | 919,250 | 606,000 |
| B/C Ratio | 2.81 | 1.79 |

Table 5. Budget analysis of IPM and Farmer Practice (Crop: Broccoli; Farmer: Pak Ujang Dayat)

| **Items** | **IPM** | **Farmer** |
|---|---|---|
| Yield (kg) | 149.2 | 192.1 |
| Price (Rp) | 4,500 | 4,500 |
| Gross Income | 671,400 | 864,450 |
| Material Costs | | |
| Seeds | 60,000 | 60,000 |
| Fertilizers + Lime | 60,000 | 163,500 |
| Animal Manures | | 200,000 |
| Bokashi | 115,500 | |
| Pesticides | | 99,000 |
| Service Costs | | |
| Land preparation and cultivation | 180,000 | 180,000 |
| Preparation of bokashi, botanical pesticide, biotic agents | 75,000 | |
| Total Costs | 490,500 | 702,500 |
| Net Income | 180,900 | 161,950 |
| B/C Ratio | 1.37 | 1.23 |

Table 6. Budget analysis of IPM and Farmer Practice (Crop: Green Onion; Farmer: Pak Ujang Dayat)

| **Items** | **IPM** | **Farmer** |
|---|---|---|
| Yield | 509 | 756 |
| Price | 2,500 | 2,500 |
| Gross Income | 1,272,500 | 1,890,000 |
| Material Costs | | |
| Seeds | 400,000 | 400,000 |
| Fertilizers + Lime | 92,400 | 257,400 |
| Animal Manures | - | 200,000 |
| Bokashi | 115,500 | - |
| Pesticides | - | 99,000 |
| Service Costs | | |
| Land preparation and cultivation | 180,000 | 180,000 |
| Preparation of bokashi, botanical pesticide, biotic agents | 75,000 | - |
| Total Costs | 862,900 | 1,136,400 |
| Net Income | 409,600 | 753,600 |
| B/C Ratio | 1.47 | 1.66 |

Tabel 7. Number and composition of leafminer parasitoids

| Collection date | Plant age (WAP) | Number of leaves | Leafminers | | Parasitoids emerged | |
|---|---|---|---|---|---|---|
| | | | Pupa Aborted | Flies emerged | *Opius chromatomyiae* | *Hemiptarsenus varicornis* |
| 03-IV-08 | 5 | 10 | 58 | 6 | 53 | 9 |
| 10-IV-08 | 6 | 10 | 34 | 8 | 13 | 14 |
| 17-IV-08 | 4 | 10 | 47 | 10 | 6 | 4 |
| 17-VI-08 | 8 | 20 | 13 | 8 | 25 | 73 |
| 17-VI-08 | 4 | 15 | 21 | 43 | 17 | 2 |
| 24-VI-08 | 5 | 15 | 28 | 15 | 21 | 11 |
| 1-VII-08 | 3 | 15 | 33 | 16 | 1 | 4 |
| Total: | | 95 | 234 | 96 | 130 | 107 |

The most important diseases of cucumber were plant wilt caused by the nematode *Meloidogyne arenaria* and powdery mildew caused by *Pseudoperonospora cubensis*. About 9% of plants wilted because of the nematode attack. Other diseases attacking cucumber were Cucumber Mosaic Virus (CMV) and leaf spot caused by *Alternaria* and *Colletotrichum*.

**Farmer field laboratories**

Members of the IPM CRSP Team at Bogor Agricultural University, in partnership with local farmers and extension agents, have established three farmer laboratories (posyantis) where microbial control agents, botanical insecticides, organic fertilizers, and composts are being produced. These materials are packaged and sold to local farmers. They are even being marketed in other locations in Indonesia including Malino, South Sulawesi, Lake Toba, North Sumatra, and The Dieng Plateau in Central Java. Products include Tronc, a *Trichoderma* formulation; Fumure, an organic fertilizer; Maladie, a botanical insecticide made from neem and Tephrosia; and Bokasi, a fermented compost. They were also beginning production of two species of endophytic bacteria, *Bacillus subtilis* and *Pseudomonas flourescen*s. Two of the laboratories, Posyanti Capung and Posyanti Pada Jaya, are located in vegetable growing areas. A third laboratory, Posyanti Sumber Arum, was being set up in a banana growing area.

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**North Sulawesi, Indonesia**

**Bioecology of *Nisiodiocoris tenuis* (Hemiptera: Miridae) on tomato**

The life cycle of *N. tenuis* was studied under laboratory conditions. The life span of this insect from egg to imago was 24 days. Studies showed that the nymphs and adults of *N. tenuis* can cause damage and crop loss.

**Isolation and application of local strain of *Trichoderma* to control vegetable diseases**

A new strain of *Trichoderma* sp. was isolated from soil at Rurukan, Tomohon and at Modoinding. The strain was tested on the cabbage crop at Rurukan by mixing it with organic fertilizer. Results showed that *Trichoderma* can reduce the incidence of crop diseases. Local strains of *Trichoderma* spp., isolated from different soils in N. Sulawesi, are being tested under laboratory conditions.

The local strains were sent to IPB and were identified as *Trichoderma koningi*, isolated from soil at Modoinding, and *T. harzianum*, isolated from soil at Rurukan. Laboratoy tests on the effectiveness of these two strains showed that both *T. coniingi* and *T. harzianum* can effectively reduce the incidence of tomato wilt caused by *Fusarium oxysporum* but there was no significant difference on the effectiveness between the two strains.

**Survey of parasitism of *Diadegma semiclausum* on *Plutella xylostella* found different species of *Brassicae***

A survey carried out at Modoinding showed that the highest average percent of parasitism by *D. semiclausum* on *P. xylostella* was on the cabbage crop with 21.33%, followed by petsai (Chinese cabbage) with 14.84 % and Chaisin with 12.03%.

**Pathogenicity of the new local strain of *Metarhizium* sp to control Lepidopteran pests on vegetable crops**

A new local strain of *Metarhizium* sp was isolated from infected larvae of *Crocidolomia pavanona* on cabbage at Rurukan, Tomohon. The pathogenicity of this strain was tested under laboratory conditions on larvae of *P. xylostella* and *C. pavanona.* It was found that the new local strain of *Metarhizium* sp. effectively infected and killed larvae of *P. xylostella* and *C. pavanona*. Results showed that application of $10^8$ of spores of *Metarhizium* can effectively reduce the damage by *P. xylostella* and *C. pavanona* on cabbage crops. The plot that used *Metarhizium* sp. produced 100% of undamaged crops compared to no treatment (control) which was only 63.3% of the crop. The average production of cabbage with treatment of *Metarhizium* was 1.66 kg/plant whereas for non treatment (control) it was only 0.84 kg/plant.

**Use of biological agents on Integrated Pest Management for potato crop**

IPM trials were conducted in a potato field using different concentrations of a local strain of *Trichoderma koningii* mixed with organic fertilizer and chicken waste. The mixtures were kept in plastic bags for a few days before mixing them with the soil at each plot. Preliminary tests showed that this strain was effective in reducing the incidence of *Fusarium oxysporum*, a causal agent of tomato and potato wilt disease.

**Training of IPM for heads of the farmers' groups in Modoinding**

Training was carried out in collaboration with the IPM CRSP team at Sam Ratulangi University and the Bureau of Agriculture, District of Minahasa. There were 30 participants, 22 men and eight women. Materials distributed included the Provincial Policy for Agricultural Revitalization, importance of IPM, the principles and components of IPM, and identifications of pests and diseases of vegetable crops and their natural enemies.

**Demonstration of mass rearing of SeNPV and *Trichoderma* sp.**

These activities were demonstrated to heads of farmers' groups and agricultural extension services in Modoinding. There were 17 participants, seven women and 10 men. Participants were taught mass-rearing of SeNPV using young larvae of *Spodoptera exigua*. Mass-rearing of *Trichoderma* was demonstrated to the farmers using corn media.

**FIELD/Indonesia**
**North Sumatra, Indonesia**

**Farmer field studies on citrus fruit fall in Karo district**

Field studies on citrus fruit fall were organized in the Suka village of the Tigapanah subdistrict, and the Serdang and Penampen villages in the Barus Jahe sub-district.

- Pruning, tree cleaning, sanitation, composting and, liquid fertilizer from citrus waste and botanical pesticides reduced citrus fruit drop, decreased production cost, and increased profit (Table 8).

**Dissemination to other villages**

The training and field study results and processes have been disseminated to local communities and government through "Field Day". The outcome was that the farmers who joined field studies at villages of Serdang and Penampen facilitated a series of discussions in other villages.

Development of botanical ingredients to grow healthy crops (e.g. compost, liquid compost, botanical pesticides) have been organized by the citrus farmer groups and disseminated to other villages.

**Dialog with stakeholders**

Information sharing has been conducted in citrus farms with Commission B of Local Parliament, Head of Forestry Service Office, Head of Sub-districts, and farmers who are reguler users of pesticides. Farmers who joined ecological citrus studies conducted several interactive dialogs at Radio Gundaling FM (a radio local in Karo district). Dialog and radio broadcasting has been facilitated by Multi-Media Campaign – Strategic Communication of USAID's ESP.

**Vegetable field schools and studies at Sibayak (Gulen) Valley**
Post-vegetable field schools and studies have been carried out at farmer fields. In addition to that, farmers organize their own network forum on ecological farming called "Ersinalsal Lembah Sibayak."

**IPM field studies in West Sumatera**
The extract of seeds from china berry, *Melia azadirach*, was tested against insect pests of chilies, cabbage, and Chinese cabbage. It was found to control *Thrips* and *Empoasca* on chilli and *Plutella* and *Crocidolomia* on cabbage.

Studies on the effectiveness of strains of the entomopathogenic fungi *Beauvaria bassiana* and *Metarhizium* against the sweet potato weevil (SPW) proved that:

- Incubation time of entomopathogenic fungi *Beauvaria bassiana* and *Metarhizium* against *Cylas formicarius* was 4 days;
- Both of *Metarhizium* and *Beauveria* had the same pathogenicity as*C. formicarius*.

**TOT for farmer trainers**
In April 2008, a TOT was conducted in Semangat Gunung village, Lembah Sibayak. The TOT was joined by 24 farmers including 18 farmers from the Lau Biang area and 6 farmers from Lembah Sibayak.

During six days of TOT, several topics were covered including basics of agro-ecosystem analysis; principles of farmer study; special topics in the field school; data analysis; how to become facilitator; community organizing; and how to manage the field school / farmer study process.

**Farmer-to-farmer study on citrus in Lau Biang**
This farmer study was started by a series of preliminary sessions in each group, discussing basic principles of the citrus plantation ecosystem. The treatments for each group were: 1) pruning vs. no pruning; 2) sanitation (of falling fruit) vs. no sanitation; 3) more compost usage (solid and liquid compost) vs. less compost; 4) other sanitation means (stem cleaning, etc.) vs. no cleaning.

Table 8. Comparison of regular farmer and ecological practices (total area 0.25 ha, mixed cropping of citrus (50 trees) and coffee (500 trees) at the Penampen village

| | **Farmer Practice** | **Ecological practice** |
|---|---|---|
| Citrus | Income from yield = Rp.12.000.000,-<br>Production cost = Rp.9.700.000,-<br>Profit = Rp. 2.300.000,- | Income from yield = Rp.10.000.000,-<br>Production cost = Rp.2.640.000,-<br>Profit = Rp.7.360.000,- |
| Coffee | Income from yield = Rp. 6.600.000,-<br>Production cost = Rp. 300.000,-<br>Profit = Rp. 6.300.000,- | Income from yield = Rp. 6.600.000,-<br>Production cost = Rp. 0,-<br>Profit = Rp. 6.600.000,- |

Farmer field days include both in-class and in-field instruction.

In August 2008, farmer trainers / FFS Alumni of Ersinalsal Lembah Sibayak were visited by a U.S. Congressional staffs delegation (Mr. Craig Higgins and Mr. Steve Marchese) and a member of the U.S. Department of State (Ms. Dorothy Raburn), together with a USAID team and the U.S. Consul General in Medan. The farmer trainers shared information on ecological agriculture and its relationship to the conservation actions of Lembah Sibayak.

**University of the Philippines / Los Baños Batangas and Laguna, Philippines**

Aurora M. Baltazar, Candida B. Adalla, Nenita L. Opina, Jhoana L. Opena

Field studies were conducted to compare alternative IPM strategies and farmers' practices in managing pests infesting eggplant. One techno-demo plot was also established at the UPLB Centre Experiment Station Agripark Techno-Demo Area to showcase IPM CRSP technologies to manage weeds, insects, and diseases infesting eggplant. IPM technologies to manage insects (fruit and shoot borer and leafhopper), diseases (bacterial wilt, phomopsis), and weeds (purple nutsedge, spiny amaranth) consisted of biological control methods (use of earwig, Trichogramma, VAM), cultural methods (stale-seedbed technique), and host plant resistance (grafting of bacterial-wilt resistant cultivars to susceptible commercial cultivars).

These methods were compared with existing farmers' practices and were found to reduce pest populations, resulting in yields which were similar to, or higher than, crop yields of plants treated with farmers' practices.

While the field studies for the first two years (2006 and 2007) were conducted in Tanauan, Batangas, the field studies for 2008 were conducted in the adjacent province of Laguna in efforts to spread and disseminate IPM technologies to more vegetable farmers in the southern Luzon area.

**Evaluation of promising component technologies to manage pests infesting eggplant in Calauan, Laguna, April –August 2008**

The seedbed was prepared by adding 10 kg /ha of VAM (vesicular arbuscular mycorrhiza) at about 0.5cm thick to autoclaved garden soil. The farmers' seedbed was not treated with VAM. Complete fertilizer (14-14-14 NPK) was applied basally to all plots prior to planting. Forty-five day old seedlings of grafted eggplant cultivar 'Casino' (for IPM plots) and 21-day old non-grafted cultivar 'Casino' (for the farmers' practice plots) were transplanted into 1.2 by 0.5m plots (15,000 seedlings/ha).

The treatments were replicated three times and laid out in a randomized complete block design.

The IPM treatments were as follows a) weed management: stale-seedbed plus 2.5cm mulch applied immediately after transplanting, followed by one handweeding at 42 days after transplanting; b) disease management: grafting 'Casino' cultivar with EG-203 (bacterial wilt-resistant cultivar developed by AVRDC) then treated with Mycovam (vesicular arbuscular mycorrhiza); c) insect pest management: earwigs (*Euborellia annulata*) released at seven and 14 DAT (20,000 earwigs/ha) followed by six releases of *Trichogramma* cards (50 Tricho cards per release) starting at 30, 34, 38, 42, 49, 56 DAT and soil-drenching of Actara (thiamethoxam, 0.025 kg ai/ha) at 21 DAT. For the stale-seedbed technique, the area was plowed once and harrowed once four weeks before planting followed by another harrowing two weeks before planting. For the grafting technique, eggplant cultivars known to be resistant to bacterial wilt (*Ralstonia solanacearum*) were used as rootstocks and grafted to a high yielding, but bacterial wilt-susceptible commercial variety of eggplant, 'Casino.'

The farmers' practices were as follows a) weed management: glyphosate (phosphonomethylglycine, 1.44 kg ai/ha) was applied to rice stubbles and existing weed vegetation two weeks before planting followed by grass cutting at one week before planting, then applied with 2.5cm mulch immediately after transplanting, followed by glyphosate (phosphonomethyl glycine, 1.44 kg ai/ha) application at 3 WAT followed by grass cutting three to seven days after glyphosate application, and another glyphosate spraying (1.44 kg ai/ha) at 6 WAT followed by two more grass cutting operations at 7 WAT and at 10 WAT; b) disease management: non-grafted Casino cultivar was used and applied with Mancozeb (0.08 kg ai/ha); c) insect management:

Furadan (carbofuran, 0.4 kg ai/ha) sprayed during replanting; followed by application of Cartap hydrochloride (0.5 kg ai/ha) 12 times (every three to four days before each harvest), and Bushwac (cypermethrin, 0.2 kg ai/ha).

In the farmers' practice plots, farmers sprayed combined Cartap hydrochloride (0.5 kg ai/ha) and Bushwac (cypermethrin, 0.2 kg ai/ha) 12 times during the season, while our IPM plots only used *Trichogramma* and earwigs (*E. annulata*) to manage the FSB pest. Total damaged fruits (non-marketable) in the IPM plots were much lower than the marketable ones, an indication of comparatively good control.

No bacterial wilt infection was observed on eggplant grown in farmers' field in Calauan. Only phomopsis blight was observed to infect eggplant fruits on both the IPM treated and farmers' plots. Higher marketable yield was obtained in IPM plots than in the farmers' practice plots.

The fresh weight of weeds in IPM and farmers' practice plots were comparable, with weeds in the farmers' practice plots lower than in the IPM plots because of the intensive herbicide (three sprayings) combined with grass cutting (four times) operations, which costs twice as much as the IPM plots. The IPM plots also yielded comparably with the farmers plots'. In the IPM plots, low-cost stale seedbed technique controlled weeds just as adequately as did the intensive weed control operations of the farmers' practice. Thus, weed control costs in the IPM plots were reduced without reducing weed control efficacy or crop yields, resulting in higher net profits (Table 9).

**Screening of potential component technologies**

The seedbed was prepared by adding 10 kg/ha of VAM (vesicular arbuscular mycorrhiza) to autoclaved garden soil. The area was plowed once and harrowed once except for plots treated with stale-seedbed technique. Thirty-day old seedlings (non-grafted) and fourty-five day old seedlings (grafted) of eggplant cultivar 'Casino" were transplanted into 0.75 by 0.5m plots (25,000 seedlings/ha). Organic foliar fertilizer (composed of fish emulsion, seaweed and guano) was sprayed at 7, 14, 21, 28, 35, 42, 49 and 56 WAT (1 L/ha/). To manage insects, earwigs (*E. annulata,* 20,000 earwigs/ha) were released at 7 and 14 WAT followed by six releases of *Trichogramma* cards (50 Tricho cards per release) at 30, 34, 38, 42, 49, 56 DAT.

Plots were replicated three times and laid out in a randomized complete block design. The treatments were 1) stale-seedbed using non-grafted plants; 2) stale-seedbed using grafted plants; 3) non-stale-seedbed using non-grafted plants; 4) non-stale-seedbed using grafted plants. Eggplant cultivars known to be resistant to bacterial wilt were grafted for use as rootstocks to the high-yielding, bacterial wilt-susceptible commercial variety of eggplant, 'Casino.' For the stale-seedbed treatment, the area was plowed once and harrowed once four weeks before planting followed by another harrowing two weeks before planting. Plots which were not treated with stale-seedbed were handweeded five times at 3, 5, 8.11 and 16 WAT. Plots treated with stale-seedbed were handweeded once at 6 WAT.

Grafting 'Casino' to bacterial wilt resistant rootstock EG 203 markedly reduced bacterial wilt infection at the end of the growing period, which was 112 days after transplanting (DAT). The grafted eggplant had only 0.45 – 0.56% bacterial wilt infection while the non-grafted eggplant had 1.48 to 4.99% infection. No marked difference on the yield of the grafted and non-grafted eggplant was observed.

Yields were highest in stale-seedbed non-grafted plots and were lower in non-stale-seedbed plots (Table 10). High yields and low weed weights in the stale-seedbed plots indicate good weed control and increasing yields over plots not treated with stale-seedbed. Additionally, this methods entails low cost of inputs compared to handweeding, thus increasing net profits for the farmer.

**Technology transfer of IPM technologies through techno-demo plots**

Technologies developed from IPM CRSP research consisting of 1) biological control of fruit and shoot borer using *Trichogramma* and earwigs; 2) grafting disease-resistant cultivar with commercial cultivars and use of VAM to manage bacterial wilt; and 3) use of stale-seedbed technique to reduce weed populations were demonstrated in a techno-demo plot at the UPLB Central Experiment Station Agripark Techno-Demo Area.

IPM technologies to manage pests in eggplant, which includes use of earwigs and *Trichogramma* to reduce leafhopper and fruit and shoot borer infestation, are only 2 to 5% of the total production costs, and are 9% lower than the farmers' practice of weekly insecticide spraying. Thorough land preparation by using the stale-seedbed technique to reduce weed populations is 10 to 20% of the total production costs, which is a reduction of about 5 to 15% compared to the farmers' practice of weekly hand weeding. However, use of grafted seedlings is 50% of the total production costs, compared to farmers' practice (non-grafted seedlings) which is 25% of total production costs, an increase of about 25% for expenses incurred in producing grafted seedlings. This practice, however, increased yields by about 30% over yields of non-grafted seedlings, which made up for the increased production costs. The use of IPM technologies resulted in a net profit increaseby about 40% over the farmers' practice.

Table 9. Eggplant yield, crop value, pest control costs, total production costs and net profit in eggplant treated with IPM and farmers' practice in Calauan, Laguna from April to August 2008.

| Treatment | Yield (t/ha) | | Crop Value ($/ha) | Weed Control Cost ($/ha) | Insect Control Cost ($/ha) | Disease Control Cost ($/ha) | Production Cost ($/ha) | Net Profit ($/ha) |
|---|---|---|---|---|---|---|---|---|
| | Marketable | Non-marketable | | | | | | |
| IPM | 5.4 | 1.9 | 2,379 | 127 | 70 | 667 | 1,293 | 1,086 |
| Farmers' practice | 0 | 0 | 0 | 231 | 155 | 274 | 1087 | -1086 |
| Farmer's practice (replant) | 3.9 | 1.5 | 1,713 | 231 | 155 | 274 | 1087 | 627 |

Table 10. Eggplant yield, crop value, pest control costs, total production costs and net profit in eggplant treated with IPM in UPLB Experiment Station, Laguna from April to August 2008.

| Treatment | Yield (t/ha) | | Crop Value ($/ha) | Weed Control Cost ($/ha) | Insect Control Cost ($/ha) | Disease Control Cost ($/ha) | Production cost ($/ha) | Net Profit ($/ha) |
|---|---|---|---|---|---|---|---|---|
| | Marketable | Non-marketable | | | | | | |
| SST, not grafted | 8.5 | 6.2 | 4,728 | 433 | 34 | 419 | 1,572 | 3,156 |
| SST, grafted | 6.7 | 5.5 | 3,714 | 433 | 34 | 1,119 | 2,236 | 1,478 |
| No SST, not grafted | 6.5 | 4.8 | 3,632 | 465 | 34 | 419 | 1,600 | 2,031 |
| No SST grafted | 6.4 | 4.1 | 3,570 | 465 | 34 | 1,119 | 2,269 | 1,301 |

**PhilRice**

**Nueva Ecija and Nueva Viscaya, Philippines**

## Technology transfer and promotion of pest management technologies in rice-vegetable cropping systems

H. R. Rapusas, J. M. Ramos, S. E. Santiago

### Training workshops

Ten training workshops for farmers and agricultural technologists and/or extension workers were conducted during the period of October 1, 2007 through September 30, 2008 with a total of 322 participants. Nine of these training sessions were conducted at the barangay level and one at the municipal level. Of the 322 participants, 246 (76%) were males and 76 (24%) were females. Generally, there were more male farmers than female farmers who participated except in one case where female participants were more (58%) than the males (42%). There were two sites where participants were all males (one each in Ilocos Sur and Ilocos Norte).

### Technical briefings

Technical briefings were also conducted in two barangays in preparation for the conduct of FFS in their respective barangays with a total of 113 participants. There were 91 (81%) male participants and 22 (19%) females. These briefings were conducted to create awareness among farmers about the availability of alternative approaches to their current pest management practices, and to arouse their interests in knowing/learning new technologies that they can implement. One of the means is through FFS. Agricultural technologists also attended these briefings.

### Farmer field schools

Five farmer field schools (FFS) on onion were conducted during the period. A total of 143 participants graduated from the season-long training or FFS. There were 108 (76%) males and 35 (24%) females. Two were conducted in Nueva Ecija and three in the Ilocos Region. These were coordinated with the LGU and the agricultural technologists concerned helped in facilitating the conduct of the FFS. More field schools will be conducted in the following year.

### Training and practicum on the mass production of VAM and *Trichoderma* sp. (T5 isolate)

Four hundred and forty-five (445) farmers were trained on the mass production of VAM and *Trichoderma* sp. during the period. Of these, 329 (74%) were males and 116 (26%) were females. There were representatives from 22 barangays in 13 municipalities and four provinces.

In northern Ilocos Sur, the LGU of Sinait, through the Municipal Agriculturist, also showed interest in putting up a small laboratory for the maintenance of the pure culture of *Trichoderma* sp. (T5 isolate) for the mass production of the organism by farmer groups. VAM production is being established in one barangay. This is being supervised by the AT assigned in the barangay.

*Trichoderma* production is still being done by individual farmers. In the other barangays, farmers have not organized themselves yet, hence, individual production of the two biological agents isdone by individual farmers. More and more farmers are requesting assistance for mass production.

### Farmers' participatory technology demonstration (PTD)

In the Guimba PTD, the incidence of anthracnose and basal plate rot diseases of onion was higher in the farmers' practice plots than in the IPM plots. Yield was also higher in the IPM plots than in the farmers practice plots, which resulted in an increase of net income by 35% over the farmers' practice. In San Jose City, yield was also higher in the IPM plots than in the farmers' plots. The demo plot in Sinait, Ilocos Sur was totally destroyed by flood and typhoon that hit the area during the onion season.

### Information campaign

One of the great events that occured this year was the launching of an information campaign on the management of common pests and diseases in rice-onion farming system in Bayambang, Pangasinan, coined as:

OPLAN SAGIP SIBUYAS

This was launched in September 24, 2008 by PhilRice-IPM CRSP in collaboration with the local government of Bayambang, Pangasinan. This was a municipal-wide activity with 401 registered participants (onion-rice farmers, extension workers, municipal and barangay officials, and students). Of these, 312 (78%) were males and 89 (22%) were females.

The campaign aimed at enhancing farmers' knowledge, attitudes, and practices on the management of common insect pests and diseases in rice-onion farming systems. This specifically lobbies the use of an IPM approach in managing pests. IPM was emphasized as more than a mere pest control method, but an environmentally sensitive approach that combines biological and cultural methods. The launching also aims to spur public awareness and support on the campaign. It was stressed that community involvement is a very important element in the success of any campaign.

The affair was highlighted by a mini parade around the municipality proper, an exhibit of campaign materials, and an open forum between the participants and the experts. There were also competitions on jingles for the campaign where farmer participants performed.

The campaign will be continuously conducted in two barangays starting in the 2008 wet season and ending in the 2009 dry season. However, after the launching, some groups of farmers have shown interest in continuing the campaign in their respective barangays. Campaign activities will include massive and intensive information dissemination via multimedia such as print, radio, TV, technology demonstrations, and farmer field schools.

Prior to the campaign launching, farmers' group discussion (FGD) was done in two barangays which will be the centers of the campaign. This was followed by farmer briefing/training. The campaign will be continued for two seasons of onion.

**Training and campaign materials**

The two new publications done through the old IPM CRSP (book on 'Integrated Pest Management in Rice-Vegetable Cropping Systems' and a 'Field Guide on Common Insect Pests and Diseases of Onion') were continuously promoted and disseminated to the LGUs and farmers in the sites, and to IPM coordinators as well as the HVCC coordinators in the provinces covered by the project.

Eight information and technology posters and eight leaflets on insect pests and diseases of onion were produced with the PhilRice Development Communications Division. These were used in support of the information campaign.

**Commercial production of Vesicular Arbuscular Mychorrhiza (VAM)**

C. B. Casiwan, H. R. Rapusas, Mike Hammig

Because of the benefits derived from the use of VAM, farmers are very interested in using this organism.

The current supply comes from individual farmers/farmer groups who are producing VAM for their own use.

These are the farmers trained by the IPM CRSP team at PhilRice. The farmers who engaged in the mass production of VAM are selling the soil innoculant at P50.00/kg.

**Survey of larval parasitoids of leafminers on vegetables and weeds in the Philippines**

G. S. Arida, B. S. Punzal and B. M. Shepard

In 2007, a total of 1434 LM larvae were collected and reared in the laboratory. Mean parasitism observed was 27%.

Most of the larvae were collected from string beans from the provinces on Luzon Island. This was followed by onions and tomatoes. The highest parasitism was recorded from larvae collected from sweet potatoes. However, very few samples were reared from this crop. The lowest parasitism was recorded on larvae collected from eggplant and radishes.

In string beans, a high incidence of parasitism was recorded in the provinces of Ilocos Sur, I. Norte, and Nueva Viscaya. All species of parasitoids were recorded on this vegetable crop. The highest was in N. Viscaya with 63%, followed by Ilocos Norte with 60%. The lowest parasitism was recorded from samples collected in Aurora and Pangasinan.

A total of nine species of parasitoids were recorded from the samples. The most common parasitoid reared from all the vegetables in 2007-2008 was *Diglyphus isaea*. *Neochrysocharis formosa* was the most abundant species reared in 2006-2007 samples. In 2007, *D. isaea* population was followed by *N. formosa*, *Opius* sp. and *Hemiptarsenus variconis*. In 2008, *D. isaea* was also the most abundant parasitoid reared from all the vegetable crops sampled.

The larval parasitoids of LM play an important role in reducing the population of this pest on vegetables. Earlier studies indicated that in the absence of insecticides in onion, damage caused by LM was generally low and did not cause significant loss in yield. In addition, there was a high incidence of parasitism and population of generalist predators in unsprayed fields. Conservation of these naturally occurring parasitoids is critical in the development of IPM strategies against LM in vegetable crops.

**Management of tomato fruitworm, *Helicoverpa armigera*: monitoring adult populations with sex pheromone-baited traps**
G. S. Arida, B. S. Punzal and B. M. Shepard

Catches of male *H. armigera* moths in sex pheromone traps showed two peaks during the crop period. These were recorded at 29 and 52 days after transplanting (DAT). Peaks in the number of eggs occurred at the same time as trap catches. The highest incidence of damaged fruits and number of larvae were recorded at 50 DAT. Results indicated the possibility that sex pheromone trap catches could be used as a monitoring and surveillance tool for timing an intervention against *H. armigera*.

**Management strategies of whiteflies in rice-based cropping system**
C. Roxas, M. G. Patricio, H. R. Rapusas and B. M. Shepard

**Evaluation of plant extracts in the management of whitefly on tomato and cucumber**. The effectiveness of plant extracts from ginger (*Zingiber offocinale*) rhizomes, *Cyperus rotundus* rhizomes, and leaves of *Cymbopogon citrarus* and *Azadirachta indica* were evaluated for the control of whiteflies on tomato and cucumber. The population of whiteflies was lower on plants applied with neem leaf and yellow ginger extracts compared to other plant extracts used.

**Effect of plastic mulches on the population of whitefly on tomato and melon.** The reflectance effect of different mulch on the whitefly population on tomato and melon was evaluated. Three types of mulch were tested – silver and yellow plastic mulch and rice straw. The yellow plastic mulch had a lower population of whiteflies than the silver and rice straw mulch.

**Kakawate (*Gliricidia sepium*) plant extract for the control of whiteflies on tomato.** Preliminary results of the study showed that 1:1, and 1:75% concentration for every kilogram of *G. sepium* leaves soaked in one liter and 1.750 liters of water, respectively, had a lower population of whiteflies compared to other treatments used.

**Farm womens' role in IPM: The case of the Philippines**
I. R. Tanzo and R. Malasa

**Sociodemographic characteristics**
The farmwomen respondents, on the average, were almost in their fifties. All respondents had some form of schooling, with Nueva Vizcaya farmers having the highest percenteage of women with acollege/tertiary education (34%). The majority of the respondents, regardless of province, were not members of any farm organization. Most of the respondents were engaged in rice farming for about 20 years already. For vegetable farming, the Ilocos farmwomen were engaged the longest (mean of 20 years), while the Nueva Ecija farmers were in it the shortest (mean of 11 years). The farm area for rice (1.77 ha) and vegetables (1.34 ha) was biggest for Nueva Ecija. About three-fourths of the farmwomen owned a knapsack sprayer. The majority of the respondents had not attended any IPM related training.

**Pesticide handling practices**
In terms of disposal of pesticide residues and containers, it is generally a family member who is incharge of these activities. Less than 10% said that they personally disposed of these materials. Manner and location of disposal for pesticide residues were generally the backyard and farm or stored inside the house. For pesticide containers, manner and location of disposal were the farm, which included with other garbage, backyard, or the containers were sold. The majority of the farmwomen reported that they wore protective gear when using pesticides. Note that for Nueva Ecija farmers, almost a quarter were not using any kind of protection. The most commonly used protective gear of were long sleeves, masks, or t-shirts/handkerchiefs/cloths tied around the head.

**Institution building**
Funds were provided to scientists to attend workshops in the Philippines and Indonesia. Local travel in relation to the conduct of the research was also provided to scientists/ researchers of the project.

**Networking activities**
Networking is accomplished through institutional collaboration among the Philippine Rice Research Institute (PhilRice), Central Luzon State University (CLSU), and the Local Government Units (LGU) of the IPM CRSP sites and the Department of Agriculture.

H. R. Rapusas was a resource person/speaker in an Onion Congress held at the Provincial Capitol of

Ilocos Sur sponsored by the Provincial Government of Ilocos Sur on November 20, 2007.

H. R. Rapusas was also a resource person/speaker in several trainings on rice and rice-based crops held at PhilRice CES and Branch Stations during the year.

**Washington State University**
**Benguet, Philippines**

**Guava mite complex**
Guava leaves from the Municipality Bahong nursery were placed on cyclamen infested strawberry plants. Within two weeks, normal leaves appeared. The predatory mite complex inhabiting the guava leaves effectively controlled the cyclamen causing damage to strawberry plants.

Six primary predatory species inhabiting guava were identified: *Amblyseius herbicolus*, *Paraphytoseius orientalis*, *Typhlodromips yandala*, *Neoseiulus longispinosus*, *Laseoseius* sp., and *Euseius ovalis*.

**Mass-rearing of *Neoseiulus longispinosus*, a native predatory *phytoseiid* mite.**

Three methods for mass production were developed including the identifying of an

**Technology transfer**
Technology transfer occurs every day on many levels. Workshops and trainings were conducted which included interested farmers, laborers, students, and academics. A handbook on small-scale rearing was developed and awaits publication. A strawberry IPM manual is currently being produced as a joint project between WSU/USAID and the Office of the Municipal Agriculturist.

**A note on gender.** The elevations of the Cordillera region of Luzon are approximately 1,500m, and in some places, over a mile high. This rare setting has allowed the production of temperate crops, many commanding much higher prices than similar sized plots of lowland crops. This may have resulted in a different socio-economic pattern affecting traditional gender roles as exhibited by lowland populations.

- High-cash value crops may affect gender roles.
- The educated "trainers" are primarily women.
- The climate may have resulted in a "farming elite" not representative of the lowlands.

Women farmers attending the meetings/trainings/workshops are either the successful ones who can afford to pay for labor, allowing time for personal training, or they are older without young families. Employees of OMAG and OPAG in positions responsible for workshop training are primarily women. The climate in the Cordilleran region is significantly different than the lowlands, and temperate vegetables and fruits are high-cash value crops compared with the traditional tropical crops found in the lowlands. These factors might allow women the luxury of attending meetings and trainings, which could also increase their livelihood. Gender issues of these "temperate" people should be compared with that of their tropical lowland relatives.

**Clemson University**
**Project coordination, collaboration on all field activities**

The primary role of Clemson University is to facilitate the implementation of the activities conducted in the various field sites by our collaborating institutions. To this end, we have traveled to all field sites and maintained close contacts with collaborators, providing advice and assistance to their work.

A unique activity, not enumerated above, is the annual workshop held to bring collaborators together to exchange experiences, report progress, and plan for future activities. In the previous two years of the project, annual workshops were held at a conference facility located in a vegetable growing area near Bogor, West Java, Indonesia and accessible to the Jakarta international airport. Representatives of each collaborating group attended the workshops and lively discussions have resulted in productive exchanges of ideas for IPM strategies that may not have been thought of otherwise. Some examples of these are the recent focus on on-farm production of Trichoderma in West Java; an activity that has a longer history in the Philippines. Similarly, in the Philippines they are now experimenting with SeNPV to control armyworm on onion; a biocontrol agent first developed in Indonesia. Grafting of tomato to disease-resistant eggplant rootstock is being done in both countries.

The workshops are conducted at a very reasonable cost compared to city conferences, and we believe the resulting interaction among participants justifies the expense. In FY07/08, the IPM CRSP workshop in Manila supplanted our customary regional workshop. In Manila we were able to achieve some of the same benefits that would have resulted from a regional effort. In the future we intend to continue holding workshops of this type.

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

*Karim Maredia, Michigan State University*

**Co-Investigators:**
Doug Landis, Michigan State University
George Bird, Michigan State University
Walter Pett, Michigan State University
Frank Zalom, University of California, Davis
**Host Countries:** Kyrgyzstan, Tajikistan, Uzbekistan
**Collaborators:** ICARDA, Thrips Transmitted Tospoviruses Global Theme, Information Technology and Databases Global Theme

**Screening of native plants for attractiveness to natural enemies of pests**
In collaboration with the Institute of Zoology and Parasitology in Tajikistan and the Kyrgyz Agrarian University in Kyrgyzstan, the IPM CRSP is continuing to conduct experiments on screening native plants for attractiveness to natural enemies of pests in Tajikistan (24 species) and in Kyrgyzstan (10 species). In both sites, experiments were randomized with four replicates for each plant species. From May to September of 2008, arthropods were sampled and identified weekly. The data for this experiment is being analyzed to assess the attractiveness of native plants to various insects.

**Introduction of successful local nectar plant into existing vegetable farming systems in collaboration with local farmers**
In collaboration with the Department of Plant Protection at the Tajik Academy of Agricultural Science, research plots on screening eight species of nectar plants for their agronomic characteristics were established in Tajikistan (Table 1). In the first experiment, nectar plant strips were established between wheat and cotton crops. In the second experiment, nectar plant strips were established between vegetable and maize crops. Both experiments were conducted in a randomized block design with five replicates for each plant species. During the experiments, arthropods were sampled weekly from flowering plants. Insects were collected by standard entomological sweep net with five samples from each plant. Insects have been identified by family and the data is being analyzed. An additional experiment was established to determine the impact of existing predators on tomato and cotton pest populations with cage affects.

In collaboration with the Tajik National TV-I, the Institute of Zoology, and Parasitology and the Department of Plant Protection at the Tajik Academy of Agricultural Science, a 20-minutefilm was developed and broadcasted on TV to popularize the role of nectar plants in biological pest management. The general topic of the film was "Landscape ecology to enhance biodiversity and biological pest management." Images from the research plots on nectar plant strips with interviews from Nurali Saidov, Anvar Jalilov, and Abdusattor Saidov were televised in two sequences on the National Tajik National TV-I.

**Publication of brochures on nectar plant diversity and beneficial insects**
In collaboration with various partners including universities, NGOs, and local institutions in Central Asia, Nurali Sidov has published papers and extension bulletins, and initiated the production of films highliting the importance of landscape ecology and habitat management for biological control. In addition, he has translated the brochure "Sunn Pest Management" into Tajik and 100 copies were distributed to farmers and plant protection and extension personnel in Tajikistan. For a complete list of these documents, please see the "Publications" section of this annual report.

**Colonization and acclimatization of *Amblyseius cucumeris* on bran mites, spider mites, and other prey in laboratory conditions**
This research component has been focusing on the study of colonization and acclimatization of *Amblyseius cucumeris* on bran mites, spider mites, and other prey in laboratory conditions. *A.cucumeris* and *A. mckenziei* are commercially important as biological agents for controlling pests on cotton and vegetable crops. The reproduction cycle of predator

mites has been understood. New methodology for rearing predator mite *A. cucumeris* has been determined in biolaboratories in Uzbekistan and Kyrgyzstan. Various experiments were conducted to assess the effectiveness of predator mites in colonizing spider mites under laboratory conditions. Results reveal that predator mites can be a potential biological agent against spider mites on crops. Favorable conditions for spider mite colonization were determined. Experiments on cotton showed that *A.mckenziei* was effective against *Tetranychus urticae.* It was established that the optimal ratio of predator mite application at pest density 300 – 400 per plant is 1:7. At high spider mite density, *A.mckenziei* should be applied two times every 12 days at a ratio of 1:50. In addition, studies have been conducted on developing methods for maintaining predator mite stock cultures during winter. The survival ability of *A.cucumeris* in winter at low and normal temperatures was determined in laboratory conditions on *Acarus farris* as prey adding different complex pollens of wild plants and orchard trees as additional food sources. The experiment showed the survival and reproduction capacity of *A. cucumeris* during winter is enhanced by a complex source of pollens.

**Laboratory experiments on vegetable in Uzbekistan and Kyrgyzstan**

**Effect of *Ambliseius mckenziei* (Acarina: Phytoseiidae) on *Thrips tabaci* (Thysanoptera: Thripidae) on onion crop in Uzbekistan and in Kyrgyzstan**

At present, the area foronion and garlic production in Uzbekistan is expanding. This increased production requires effective measures for protecting the crops against pests and diseases. The most important insect pests of onion and garlic crops in Uzbekistan is *Thrips tabaci*. Thrips damage to onions results in both loss of yield and reduction in storage quality of onion bulbs. Thrips are most damaging during the early bulb development stage. Infested plants may have leaves that are scarred (stippled appearance) and do not elongate properly, resulting in twisted or crinkled leaves. With green onions, leaf scarring reduces marketability. According to our observations, thrips come out of overwintering sites at the beginning of April, first occupying weeds and then moving into onion fields. The highest thrip population occurs in April, averaging 50 individuals per plant.

**Biological control of *Thrips tabaci***

*Neoseiulus* (*Amblyseius*) *mckenziei* (Barkeri) Hughes (Acarina: Phytoseiidae) is an oligophagous predatory mite. It has been mass-reared with storage mites such as *Acarus farris* (Oudemans) as prey for control of thrips (*Thrips tabaci)* Lindeman on cucumbers and peppers in many parts of the worlds. In 1981, the predator *A.mckenziei* was introduced in the former Soviet Union and in 1983 it colonized Central Asia. At present, in Kyrgyzstan biocenter, mass production of this predator is being commercially done for control of onion thrips and spider mites on various crops.

Biological control of *Thrips tabaci* using the predator *Amblyseius mckenziei* was studied during the spring and summer on onion in field plots that consisted of three strips and 30 plants for each predator release. *Amblyseius mckenziei* was successfully colonized on grain mites *Acarus farris* and plant pollens in 3l glass jars that were maintained in growth chamber at a temperature of 25±1° C and relative humidity 60±10%. *A. mckenziei* were introduced two-three times and different rates into different densities of *Thrips tabaci* ranging from five to 50 per square meter.

Table 1. List of plant species established at the nectar plant strip in Tajikistan, 2008.

| | 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 | Lamiaceae (Labiatae) | *Ziziphora interrupta Juz.* | Interrupta | Forb |
| 5 | Lamiaceae (Labiatae) | *Ocimum basilicum L.* | Sweet basil | Forb |
| 6 | Balsaminaceae | *Impatiens balsamina L.* | Balsam | Forb |
| 7 | Asteraceae (Compositae) | *Pyrethrum carneum* | Pyrethrum | Forb |
| 8 | Asteraceae (Compositae) | *Tagetes erecta L.* | African marigold | Annual |

Results showed that the predator was effective at different pest densities up to 50/m², with an efficiency of 77.6±3 % on the $17^{th}$ day after the predator was released. A high predator efficiency of 90.2 ± 3% was observed at the beginning of pest attack. This indicates that the predator can adequately prevent or suppress pest build up if applied early enough. The predator was more effective if released when the pest density was still low (predator: thrips ratio 1:3 at temperature of 25° C). When pest density is very high, the predator can suppress pests if applied at a ratio of 1:1 three times every 12 days.

***Amblyseius cucumeris*** **feeding on whiteflies in tomato plant**

The effects of *A. cucumeris* release rate on *T. vaporariorum* populations were determined in both a laboratory and greenhouse studies.

For the laboratory study, *T. vaporariorum* were collected from tomato plants in an infested greenhouse and then placed on tomatoes grown in the laboratory on liquid medium in 3l jars. The predator and prey were released into the jars at ratios of 3:1, 1:1, and 1:2, with a *T. vaporariorum*-only control. Whitefly eggs were counted daily. Additional *A. cucumeris* were released at 5, 15, and 25 days following the initial release.

The greenhouse experiment was conducted in a 60 m² greenhouse on the spring tomato crop. The treatments were established in separate strips with 20 plants in each strip and four replicates. Four to 8 plants in each replicate were infested with *T. vaporariorum* at a rate of 10 adults per plant. *A. mckenziei* were released at the same time at predator-prey ratios of 3:1, 1:1, and 1:2, with a *T. vaporariorum*-only control. Additional *A. cucumeris* were released at 5, 20, and 30 days following the initial release. The whitefly population density was determined daily by counting the number of whitefly eggs in each strip.

The average number of whiteflies per plant at release ratios of 3:1, 1:1, and 1:2 were reduced relative to the no release control in both the laboratory and field studies for the 35-day post-release period. However, whitefly egg densities continued to increase following the release at all ratios and in the no release control. The 3:1 release ratio provided the best control in both the laboratory and field study.

**Development of IPM Training program in Central Asia universities**

To enhance the university education, Dr. Aitmatov has conducted an inventory and analyzed IPM education programs in Central Asia. Data on IPM training programs at agricultural universities in Central Asia was collected from the Kyrgyz Agrarian University, Kazakh National Agrarian University, and Kuban State Agrarian University. It was observed that there are differences in IPM-related training programs. For example, in Kazakhstan, the IPM training program focuses more on grain crops, whereas in Kyrgyzstan, in addition to grain, they focus on vegetable and fruit crops. The IPM training at the Kyrgyz Agrarian University is almost a replicate of the Russian training program. Based on this assessment, an IPM training program has been developed for the Student Field School (SFS). The first teaching program on IPM was initiated in November 2007 and class started in March 2008. Fifteen students (3 female and 12 male) were selected for the SFS, and some of them are working on various research topics including introduction of nectar plant into existing vegetables farm systems as a method of conservation of natural enemies in agroecosystems, impact of mulching on soil microflora, resistance of different wheat varieties to cereal leaf beetle, and design of landscape. Dr's. Saidov and Aitmatov are providing the supervision for these research projects. Six lecturers and scientists selected from the Agrarian University and Biology-Soil Institute of the Kyrgyz Academy of Sciences have undergone a one-month course on facilitating Farmer Field School and Training of Trainers.

The IPM CRSP Program Central Asia has been working with the Kyrgyz to develop an IPM teaching curriculum and provide support to IPM training programs organized by ATC. The Agrarian university (size=500 students) offers a higher education diploma (a 4.5 year program) in agriculture/agronomy. In collaboration with IPM CRSP, the Kyrgyz have plans underway to start offering IPM specialization in September 2009. IPM courses will be developed to teach students in their fourth year as a specialization. Currently, as a pilot initiative towards this plan, six senior students are working on IPM research projects with IPM CRSP funding. These students were selected from a pool of 30 potential students. They will graduate with a degree in agronomy and a specialization in IPM. The long-term goal is to establish a national IPM center in collaboration and partnership with the Kyrgyz Agrarian University, National Academy of Sciences, the Botanical Garden, Ministry of Agriculture (Department of Pesticides and Plant Protection, Department of Forestry, Department of Quarantine and Inspection, etc.). The goal is to train the best IPM trainers. The task of this center will be to develop the curriculum on IPM and establish educational facilities such as laboratories, gather equipment, and create an IPM teaching and research infrastructure.

Since the government has no extension system, the ATC-Rural Advisory Service (RAS) — established by the World Bank in 1998 -- is providing extension services through Farmer Field Schools (small-scale with each FFS having 10-15 farmers). The IPM CRSP project in Central Asia, through the extension and outreach component, provides support to IPM related activity initiated by ATC to train master trainers and develop education and training materials for the TOT courses.

**Publication of brochures and leaflets on various IPM issues and update of the IPM directory**

Murat has published many extension bulletins for use by farmers. Various trainings were also held focusing on methodology of IPM technology transfer to Training of Trainers, Farmer Field School, and Student Field School. In collaboration with the World Vegetable Center and AVRDC-CAC, the IPM CRSP project in Central Asia has published a brochure "Weed in vegetable crops in Central Asia." The brochure "Sunn pest management" has been translated into Kyrgyz and 100 copies were distributed to farmers and plant protection extension personnel in Kyrgyzstan. The brochure "The Botanical pesticides" has been published and 300 copies were distributed in Russian and Kyrgyz. A manual on "Strengthening Students' research capacity using Student Field School" was developed by the IPM CRSP project in Central Asia in collaboration with the ATC and provided to the Kyrgyz Agrarian University. The electronic catalogue on IPM specialists in the region has been completed with new data from scientists in Uzbekistan and Kyrgyzstan.

**Evaluation of wheat nursery for resistance to cereal leaf beetle (CLB)**

In the last decade, cereal leaf beetle (*Oulema melanopus L.)* has become an important pest of wheat and barley in the Central Asia region. The goal of this study wass to conduct research on screening 60 wheat lines for resistance to cereal leaf beetle (CLB), and survey cereal leaf beetle parasitoids in Central Asia region.

**Screening of wheat varieties for resistance to cereal leaf beetle (CLB)**

In collaboration with the Institute of Plant Protection and Quarantine, a screening of wheat varieties for resistance to cereal leaf beetle was conducted. The experiment consisted of 130 wheat entries (increased from wheat 60 lines) obtained from the Biodiversity and Integrated Gene Management Program (BIGMP) of ICARDA. The comparison of 130 wheat lines showed different responses to cereal leaf beetle infestation. Some lines showed no infestation whereas others showed low-scale infestation. It should be noted that during the first year of the trial, wheat lines were conducted on comparatively low CLB infestation. The low population of CLB presence in wheat fields was due to dryweather in the spring of 2008.

**Participation in regional IPM meetings and forums organized by ICARDA, Winrock International and other NGOs**

The three IPM CRSP team members regularly attended regional meetings/conferences to present the USAID IPM-CRSP project activities.

- In May 2007, Dr's. Saidov, Aitmatov, and Tashpulatova attended the IPM CRSP workshop in the Philippines.
- Dr. Nurali Saidov participated in a one-month long IPM internship at MSU in June 2008.

**Publication of the proceedings of the Central Asia Regional IPM forum held in May 2007 in Dushanbe, Tajikistan**

A regional IPM forum was held in Dushanbe, Tajikistan from May 27–29, 2007. Proceedings covering topics discussed during this IPM forum were published in February 2008. The proceedings of this forum highlighting major IPM challenges in Central Asia and areas of intervention by national and international programs have been prepared.

**Participation of IPM specialists from the Central Asia region in the MSU's International Agroecology, IPM, and Sustainable Agriculture short course**

One participant, Zarifa Kadirova from Uzbekistan, participated in a one-month internship program at Michigan State University (MSU) and Washington State University (WSU). She spent two weeks at WSU learning about virus diagnostic in Naidu Rayapati's Laboratory. The last two weeks of her internship were spent at MSU, where she attended the International Short Course IPM. The objective of the internship was to build human capacities of institutions in Central Asia.

**Baseline survey of pest management practices in Kyrgyzstan and Uzbekistan or Tajikistan**

From July 20-31, 2008, Richard Bernsten and Mywish Maredia from the Department of Agricultural, Food and Resource Economics at Michigan State University traveled to Central Asia to conduct a baseline assessment of the IPM CRSP program in Central Asia.

**The focus of baseline data/information collection in each of these countries was as follows:**

- Uzbekistan: The status of biolabs, including 1) the availability of biocontrol agents; 2) mass-rearing practices and 4) the dissemination of bioagents by labs, government, and NGOs.
- Kyrgyzstan: The status of IPM-related training and outreach, including 1) available training resources for academic programs; 2) inclusion of IPM in academic program curriculum; 3) status of farmer field schools, 4) availability of IPM training resources for outreach programs, and 5) inclusion of IPM material in extension programs.
- Tajikistan: The status of IPM CRSP activities related to the: 1) initiatives to collect native plants/species that are good sources of nectar for arthropod species, 2) introductions of native plants/species as sources of nectar for arthropod species; and 3) methods used to control pest (counterfactual).
- General Impressions: The trip was very productive and informative. The research/extension fellows have a very small operating budget; but have been very productive despite limited resources. The socio-economic team was extremely impressed with the research/extension fellows, their respective research programs, and the strength of relations that they developed with their host-country colleagues. The project has generated numerous outputs including publications, manuals, and outreach materials.

# Integrated Pest Management of Specialty Crops in Eastern Europe

*Douglas G. Pfeiffer, Virginia Tech*

**Co-Investigators:**
Milt McGiffen, University of California, Riverside
Sally Miller, The Ohio State University
**Host countries:** Albania, Moldova, Ukraine
**Collaborators:** Plant Protection Institute, Durrës, Albania, Institute for Plant Protection & Ecological Agriculture, Moldova, Plant Protection Service, L'viv and Odesa, Ukraine, Dnipropetrovsk State Agrarian University, Ukraine, and International Plant Diagnostics Network.

**Baseline Survey in Tomatoes and Cucumbers**

A survey instrument was developed and translated into Albanian, Ukrainian, Russian, and Romanian. Sixty farms were surveyed in Moldova and in each of the three oblasts in Ukraine (L'viv, Odesa and Dnipropetrovsk). Three hundred people were surveyed in Albania. Results from Albania and Moldova have been translated back into English; translation of Ukrainian results was received this summer and writing is underway.

Sixty families were targeted and asked a standardized set of 113 questions that addressed knowledge of pests, pest management concerns, size of farm families, division of farm decision-making, and farm economics. Using Moldova as an example, about a third have planted new orchards, vineyards, or built new greenhouses since privatization. About 42, 54, 48, and 0% applied insecticides to totomato, cucumber, apple, and grape crops respectively, whereas 73, 88, 37, and 96% applied fungicides. Price and specialists' advice were almost equally regarded as the most important factors in making pesticide selections, whereas 18% thought that pesticide dealers' advice was somewhat important. About 43% attributed any health problems for themselves or anyone in their family to pesticides. The three most severe tomato pests are phytophthora, tomato fruitworm (*Helicoverpa armigera*), and Colorado potato beetle (*Leptinotarsa decemlineata*). The three most severe cucumber pests are peronospora, mildew, and aphids. The three most severe grape pests are downy mildew, oidium (powdery mildew), and grape berry moth. The three most severe apple pests are codling moth, apple scab, and mildew. When asked if applying pesticides would increase yield, 90% replied yes. When asked if applying pesticides could stimulate a pest infestation, 65% said yes. The percent applying pesticides in each crop were: tomato: fungicides 85%, insecticides 64%, and herbicides 18%: cucumber: fungicides 88%, insecticides 50%, herbicides 25%; grapes: fungicides 100%, insecticides 25%, herbicides 0%; apple: insecticides 51%, fungicides 46%, herbicides: 9%. Only 17% have attended training sessions in the last five years, though 70% would be interested. When asked if an agricultural technician who discussed non-pesticide means of controlling crop pests ever visited the farm, 67% replied no. Almost half of the respondents felt that they did not have access to adequate information. In each country, a subset of farms was selected where both the husband and wife were interviewed. This will allow a gender analysis of IPM knowledge and practice. This survey not only will enable more quantitative descriptions of the state of IPM, but will allow measurement of progress in research and extension during the project.

**Implementation of IPM scouting programs for cucumber crop production in greenhouses**

J. Tedeschini, H. Paçe, E. Çota, Sh. Shahini, S. Gjini, and D. Pfeiffer[3]

An IPM demonstration project on cucumber crops cultivated in greenhouses was conducted in the main region (Lushnjë) of vegetable production in Albania. The findings for the autumn of 2007 have helped to establish new methods for monitoring key pests and diseases, economic injury levels, and sampling strategies for each of the major pests of cucumber crop. Scouting programs for these pests and diseases can be improved and timely application of pesticides has resulted in a significant reduction in production costs and hazards to farmers and the environment. The scouting program from September to November resulted in 58.76% fewer pesticide applications and a 28.1 % savings (4553.3 leke / 0.1ha) without affecting plant quality and saleability.

**Implementation of IPM scouting programs for tomato crop production in greenhouse**
J. Tedeschini, H. Paçe, E. Çota, Sh. Shahini, S. Gjini, D. Pfeiffer

An IPM demonstration project on tomato crops cultivated in greenhouses was conducted in the main region (Lushnjë) of vegetable production in Albania. Plant protection specialists and the grower of one tomato greenhouse were responsible for pest monitoring, record-keeping, and weekly meetings to make pest management decisions based on the information collected. Comparisons were made between the IPM treatments vs. the grower's conventional pest control practices. Results indicate that the scouted greenhouse resulted in reduced pesticide usage without affecting plant quantity and quality. This was achieved at a lower overall cost, even with the increased labor for monitoring.

**Arthropod management in tomatoes and cucumbers**

**Evaluation of botanical insecticides to control whitefly (*Trialeurodes vaporariorum*) on tomato**
J. Tedeschini, E. Çota, Sh. Shahini, D. Pfeiffer

This study was conducted during the first season of tomato crop cultivation in greenhouses in Radë (Durres Region). The objective was to evaluate if entomopathogenic fungi and other botanicals exhibited control on whitefly adults and nymphs. A randomized block design was used with five replications and six treatments, consisting of applications of Naturalis (*Beauveria bassiana*), Neemazal – T/S (Azadirachtin), UFO (ultra fine oil), and Keniatox (Natural Pyrethrum), compared with a standard insecticide (Ramplan (acetamiprid)) and untreated control. The response variables were the number of whitefly adults and nymphs for each leaf. The number of adults and nymphs per leaf was similar in treatments using entomopathogenic fungi as with treatments using natural pesticides, both of which showed less than absolute control.

**Reduced-risk pesticides in the control of glasshouse whitefly on tomato**
J. Tedeschini, E. Çota, Sh. Shahini, S. Gjini, D. Pfeiffer

The efficacy of Ramplan 20Sp (a.i. acetamiprid), compared with Plenum 50WG (a.i pymetrozine ), Ronin 25WP (a.i. buprofezin), and Actara (i.a. thiomethoxam) in greenhouse control of whiteflys (*T.vaporariorum*) on tomato, was investigated. All investigated insecticides significantly decreased the number of whitefly adults and nymphs, compared with untreated plots where population density grew during the trial. Actara and Plenum controlled the adults very well with the lowest population level of adults. Ronin and Ramplan were less effective. Based on the data obtained, the best efficacy on whitefly nymphal control was provided by the insecticide Ronin, followed by Ramplan.

**Insecticides and natural compounds for aphid control on greenhouse tomatoes**
Sh. Shahini, J. Tedeschini, E. Kullaj, D. Pfeiffer

This study was re-conducted on greenhouse tomato plants in Durres (Albania) in 2008, with the aim of testing several plant protection products (PPP), some of which are of natural origin (bio-insecticides). Two experiments were carried out. While the first experiment consisted of weekly aphid monitoring by counting aphids on color traps as well as plant infestation rates, the second experiment included analysis of tomato plants for the level of infestation three days before and seven days after the treatments. A block of 440 plants was allocated to 10 chemical treatments plus control with four replications. The treatments used were Rotenone, *Beauveria bassiana* (Naturalis), thiamethoxam (Actara), thiacloprid (Calypso), acetamiprid (Ramplan), pymetrozine (Plenum), natural pyrethrum (Kenyatox), azadirachtin (Neemazal-TS), UFO, pyridaben (Esamite 20 WP), and untreated control. The results of this year showed that the aphid population reaches its peak a little earlier during May with about 15% of the plants infested and about 1,000 individuals per plant. Such populations exceed the action threshold of about 10% of leaves infested. The natural compounds, besides offering several benefits in terms of product safety for human health and the environment, also provided good control (more than 60%) against aphids. These results can be used as a basis for the effective implementation of an IPM strategy for the control of aphids attacking tomatoes in greenhouses.

**Miticides to control twospotted spider mites (*Tetranychus urticae*) in cucumber greenhouses**
J. Tedeschini, Dh. Shehu, E. Çota, Sh. Shahini, S. Gjini, and D. Pfeiffer

The twospotted mite *(Tetranychus urticae*) is a serious pest of cucumber in all Albanian growing areas in protected cultivation. Mite infestations are difficult to control due to the lack of satisfactory control measures, whether old chemical or other. Failures in chemical control of spider mites caused by resistance have been reported for various compounds. New miticides were tested to improve control. The effectiveness of several botanicals was compared to the standard farmer approach to control this pest. Treatments were replicated five times in a randomized complete block design. *Tetranychus* counts were made twice. The first count was made before the treatment and the second one a week later. Results indicate that significant differences were found in *Tetranychus* populations between the different treatments and untreated control. The control effect of botanicals (Naturalis, Neemazal-ST/, etc) was similar to that of chemical treatment (Figure 1).

**Disease management in tomatoes and cucumbers**

**Evaluation of fungicides for botrytis control of greenhouse tomato**

J. Tedeschini, H. Paçe, D. Pfeiffer

A fungicide trial was established in a commercial unheated plastic greenhouse at the Kemishtaj Lushnjë region to evaluate efficacy of several fungicides for control of botrytis on tomato. Treatments Teldor SC 500 (fenhexamid a.i.), Botrilan 500 SC (iprodione a.i.), Daconil 72 SC (chlorothalonil a.i.), and Pyrus 400 SC (pyrimethanil a.i.) were applied as single treatments every seven-10 days to each of five replicates. In samples to determine the severity index of leaf area affected by botrytis and the number of fruits infected within different treatments, Teldor, Daconil, and Pyrus were significantly different from non-treated control. Although Botrilan was different from the control, this treatment had more leaves and fruits infected than other treatments.

**Evaluation of fungicides for botrytis control of greenhouse tomato**

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A fungicide trial was established in a commercial unheated plastic greenhouse at the Lushnjë region to evaluate efficacy of several fungicides for control of botrytis on tomato. Treatments Teldor SC 500 (fenhexamid a.i.), Botrilan 500 SC (iprodione a.i.), Daconil 72 SC (chlorothalonil a.i.), and Pyrus 400 SC (pyrimethanil a.i.) were applied as single treatments every seven-10 days to each of five replicates. In samples to determine the severity index of leaves area affected by botrytis and the number of fruits infected within different treatments, Teldor, Daconil, and Pyrus were significantly different from non-treated control (Figure 2). Although Botrilan was different from the control, this treatment had more leaves and fruits infected than other treatments.

Figure 1. Effect of treatment with miticides against twospotted spider mites in cucumber, Kemishtaj-Lushnje, 2008.

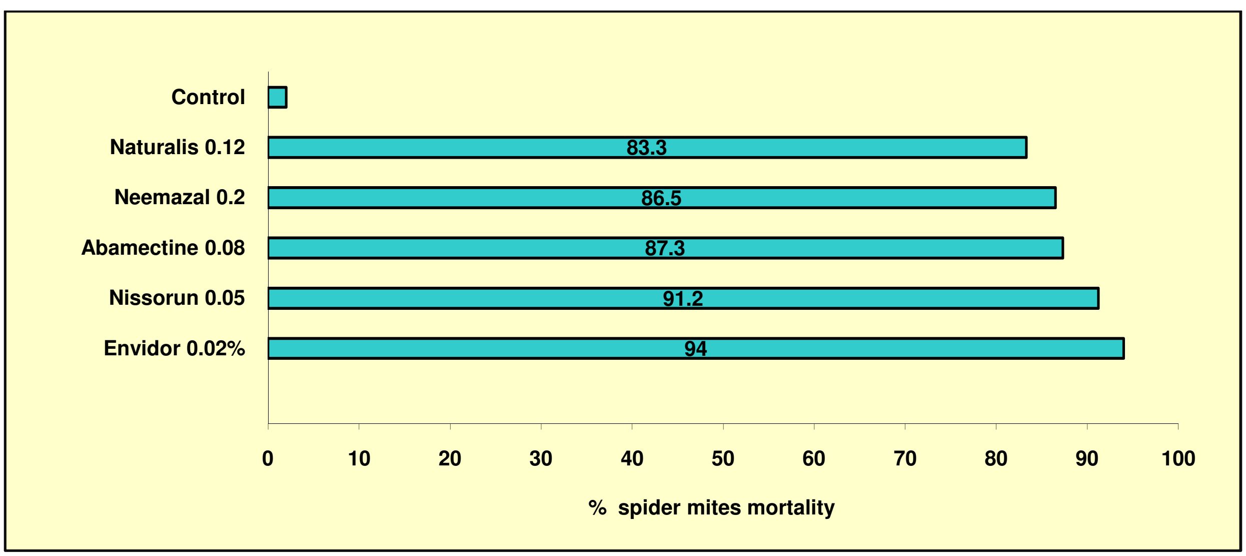
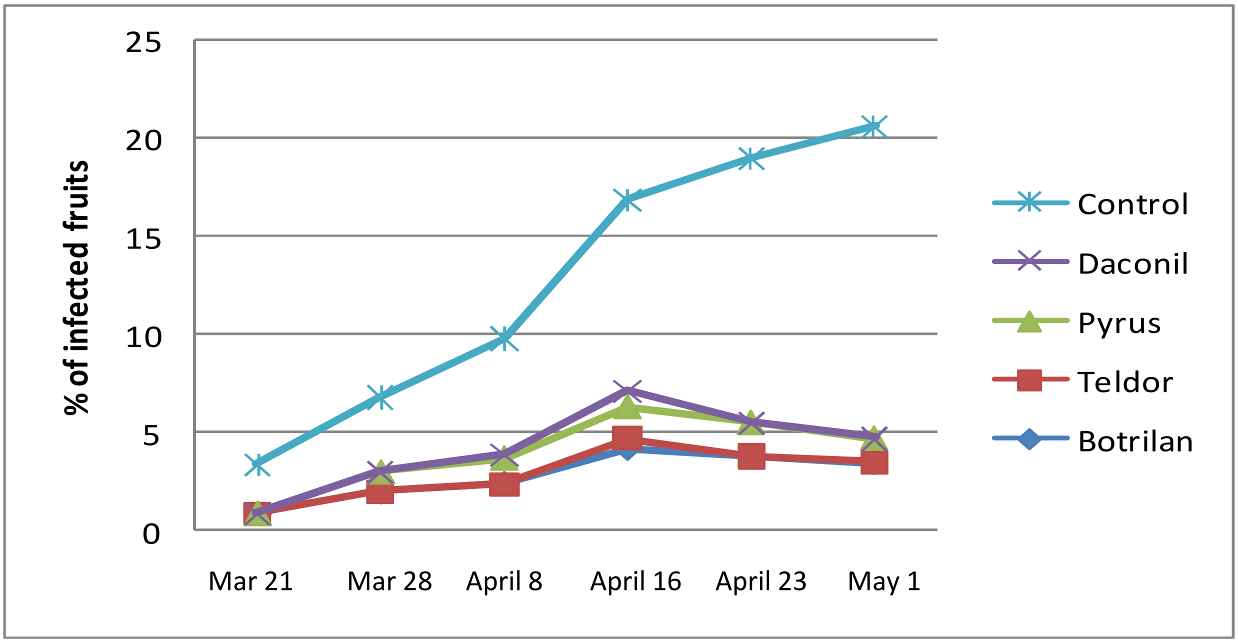


Figure 2 Effect of various treatments on percent diseased fruits infected with *Botrytis cinerea*




Compared to the untreated control, Teldor and Daconil significantly reduced the number of infected ripening fruits. By the third application, plots treated with Teldor and Daconil had lower disease ratings than any other treatment. After the fourth application, there were no significant differences in disease control among treatments.

**Grafting to reduce incidence of corky root in Albania**

J. Tedeschini,V. Jovani, H. Paçe, B. Alushi, D. Pfeiffer

The soil-borne fungal disease corky root of tomato, caused by *Pyrenochaeta lycopersici*, is a disease of concern for many tomato-growing areas in greenhouses using soil as a growing medium. The disease has been identified as one of the most common and economically important in Albanian tomato production. Chemical soil disinfection has been the method of choice in several farming systems. This method is extremely expensive and has been increasingly restricted for environmental reasons. The use of grafting onto resistant rootstocks was evaluated during the autumn of 2007 as a potential replacement of chemical control. The influence of grafting methods for the control of corky root was studied in two greenhouse trials in Albania. The cultivar used as scion was cv.'665' on the rootstock 'Beaufort'. Grafted and non-grafted plants of tomato (*Lycopersicon esculentum*) were grown in naturally infested soil in Israeli-type greenhouses in the Tirana and Kruja regions. Grafting was found to be effective in reducing root disease and increasing root fresh and dry weight, fruit yield, and number. The result showed that the incidence of tomato plants infected by corky root was 2.2-6.7% and 40-80% in grafted and non-grafted plants, respectively. The results recorded on tomato by evaluating the marketable yield showed the significant effects of grafting. The use of grafted plants enhanced the yield (+110-147%) (Figure 3).

Using the Hedon scale to determine the overall acceptance of the grafted tomato fruits, the fruit from the Beaufort rootstock were comparable to the fruits from non-grafted tomato plants, so the quality and qualitative fruit characteristics were not affected by grafting. Grafting is thus considered an important technique for sustainable greenhouse production of fruit-bearing vegetables and represents a promising non-chemical alternative for soil-borne disease control.

The use of grafting tomato scions onto Beaufort rootstock could be an effective way of growing tomatoes in areas with high corky root incidence. This would reduce the need for pesticide and increase the yield of tomatoes. Several farmers became interested and they plan to try the grafted tomato on their individual farms

**Grafting method as an alternative for root-knot nematode control in greenhouse tomato production systems**

J. Tedeschini, V. Jovani, B. Alushi, D. Pfeiffer

In Albania, root-knot nematodes are widely distributed, causing significant economical losses. A field experiment was performed in heavy clay soil, naturally infested with *Meloidogyne incognita* to evaluate the effectiveness of grafting for the control of root-knot nematode on tomato in the second season. Results indicate that compatibility of solanaceous rootstocks showed different compatibility with the tomato scions. Percentage catch of grafted tomato on Beaufort rootstock was higher than in Interga rootstock (Table 1). Under moderate nematode densities, yield on resistant rootstock was higher and root gall index at final harvest was lower. Grafted plants produced significantly higher yields (Table 2).

The use of grafting tomato scions onto Beaufort rootstock could be an effective way of growing tomatoes in areas with moderate infestation of root-knot nematode. This would reduce the need for nematicides and increase the yield of tomatoes. The use of root-knot nematode-resistant tomato cultivars is an attractive alternative for nematode management, as their use does not require major adaption in farming practices. Several farmers became interested and they plan to try the grafted tomato on their individual farms.

**Effect of BioNem, Nemafung, and Softguard on control of root-knot nematodes (*Meloidogyne* spp.) on pepper grown in unheated plastic greenhouses**

V. Jovani, J. Tedeschini, A. Ramadhi, D. Pfeiffer

Field experiments were conducted to evaluate the effect of bio-nematicide BioNem (*Bacillus firmus*) and two other products, Nemafung and Softguard (bio-stimulant and repellent), against root-knot nematode on pepper grown in unheated plastic greenhouse. Initial results indicate that in the plot treated with BioNem, the population of nematodes in the soil was reduced by 25%. The other treatments with bio-fertilizers did not seem to have any significant effect on nematode population. The experiment during the end of the harvest period demonstrated that BioNem treatment had the lowest root gall-index and significantly increased the yield of pepper production.

Figure 3. Effects of grafting resistant rootstock on yield of tomatoes/plant

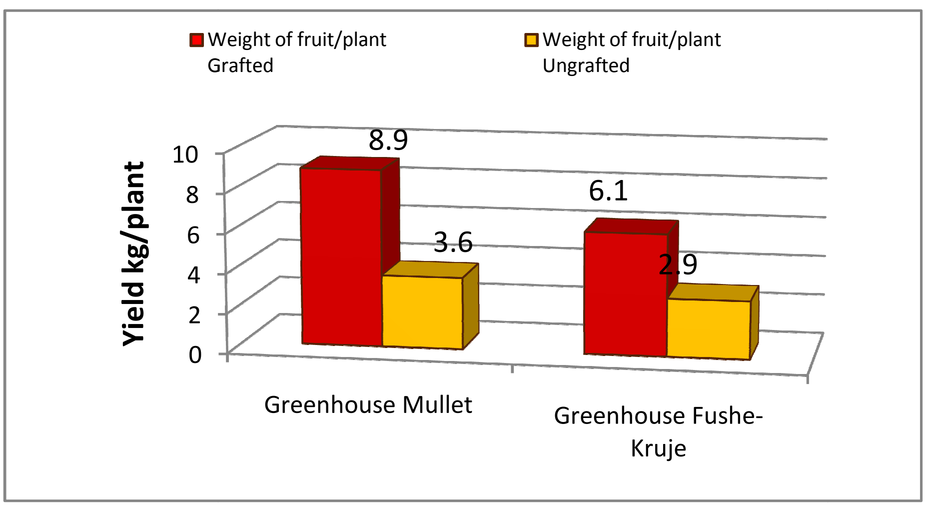


Table 1. Percentage of catch/take-off of tomato scions grafted on different root stocks, one month after grafting

| Rootstock | Percentage catch % |
|---|---|
| *Beaufort+scion DRW 665* | 80 |
| *Beaufort+scion DRW4131* | 80 |
| *Intergra+scionDRW665* | 60 |
| *Integrat+scionDRW4131* | 0 |

Table 2. Effect of grafting for the control of root – knot nematode (*Meloidogyne incognita*) on tomato plants in an unheated Israeli type greenhouse Mullet (Tirana) during second season 2007.

| Treatment | Surface of treatment ($m^2$) | Larvae density per 100 ml soil | | Root gall index (0-5) | | Yield t/ha$^{-1}$ |
|---|---|---|---|---|---|---|
| | | Pre-treatment | Post-treatment | Pre-treatment | Post-treatment | |
| *Untreated Control(non-grafted tomato) 665* | 250 | 1520 | | 3.5 | 1.5 | 48 |
| *Grafted tomato on resistant rootstock Beaufort 665* | 250 | 1520 | | 3.5 | 1 | 64 |

Figure 4. Effects of soil solarization on the severity of corky root disease

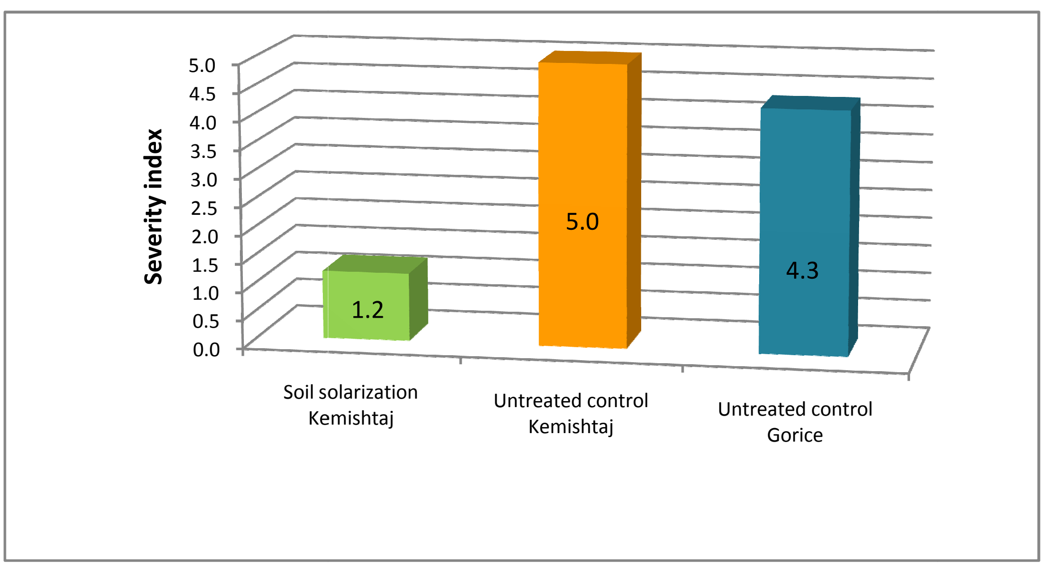
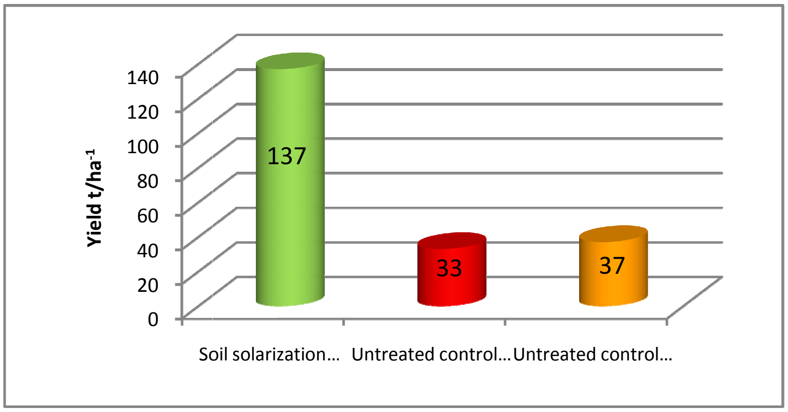


Figure 5. Effects of soil solarization on yield of tomato fruits/plant




**BioNem, Nemafung, and Softguard on control of root-knot nematodes (*Meloidogyne* spp.) on pepper grown in unheated plastic greenhouses**

V. Jovani, J. Tedeschini, A. Ramadhi, D. Pfeiffer

Field experiments were conducted to evaluate the effect of bio-nematicide BioNem (*Bacillus firmus*), plus Softguard and two other products, Nemafung and Softguard (bio-stimulant and repellent), against root-knot nematode on pepper grown in unheated plastic greenhouse. Initial results indicated that in the plot treated with BioNem plus Softguard, the population of nematodes in the soil was reduced by 56%. The other treatments with bio-fertilizers did not seem to have any significant effect on nematode populations.

**Soil Solarization for Controlling Soil-borne Fungi in Tomato Plastic Greenhouses in Albania**

J. Tedeschini , H. Paçe , D. Pfeiffer

Increasing concern for the environment in Albania has stimulated the research for environmentally sound disease control including soil-borne fungal management under farm conditions. Hence, the effectiveness of soil solarization for corky root (*Pyrenochaeta lycopersici*) management in a naturally infested plot of tomatoes in the Lushnjë region was evaluated using transparent polyethylene (PE) mulches during July andAugust of 2007. After land preparation, the moist soil was covered with transparent mulches and two other plastic houses were left uncovered as a control. The soil temperature was measured up to 20cm depth. The transparent mulches significantly increased the soil temperature which resulted in proper control of corky root disease and increase in tomato yield. Results obtained indicated that the maximum temperatures of $51^0$-52.40 $C^O$ were observed at a depth of 20 cm in the heavy clay soil in Kemishtaj Lushnjë. The native fungal populations in covered moist soil were significantly reduced in comparison with the uncovered treatment. At the end of harvest season the incidence of *P. lycopersici* was 2% and 100%, respectively. In the soil solarization treatment, the severity of root damage was 1.2 compared with 4.3-5 registered in the control (Figure 4). The difference in root fresh and dry weights between plants grown in solarized soil and the untreated control used as a measure of overall root damage by the soil borne pathogen were 41.3g, 8.5g, 15.8-20.3 g, and 3.1-3.3g, respectively. The method was also responsible for a significant increase in yields (about four fold), as well as for improving the growth of tomato plants. Based on these encouraging preliminary results, it is recommended that the solarization method for soil-borne management in plastic greenhouses is an environmentally sound, profitable, and easy agricultural practice which should be implemented in Albania.

The growth of tomato plants, as indicated by visual assessment, was significantly improved by solarization, especially in the first crop after treatment. Likewise, tomato fruit yield in the solarized plastic greenhouse was more than 350% higher than those obtained in untreated check plastic *greenhouses (Figure 5).*Solarization is simple and economic in its application, environmentally friendly, and leaves no toxic residues for humans, animals, and plants. These attributes make solarization suitable for application in a wide variety of production system.

Solarization is also known to improve plant growth and yield through the release of nutrients induced by high soil temperatures.

**Soil Solarization, a non-chemical method to control root-knot nematodes (*Meloidogyne spp)* and improve the yield of greenhouse crops**

V. Jovani, J. Tedeschini, A. Ramadhi, D. Pfeiffer

Tomato and lettuce cultivation in Albania are susceptible to infection by soil-borne diseases and severe yield losses can result. The effectiveness of solarization, a soil disinfection technique that uses passive solar heating to control the incidence of roo-t knot nematode under greenhouse conditions, was studied during the second crop of 2007 in the Lushnjë and Tirana regions. Solarization was accomplished by the application of 0.05-0.06 mm clear polyethylene sheets to moist soil for four weeks during the hot season. The treatment increased the maximum soil temperature bymore than $50^0$C at 20cm below the soil surface, whereas this temperature was not reached at all in unmulched soil. In solarized soil, no galls were found on tomato roots. The treatment reduced nematode populations 87-100% of the time on tomato and lettuce. In non-solarized plots, the infestation was present at a high density, with decreased plant growth and crop production. Tomato fruit yield was 403-415% higher in the solarized soil compared with the non -olarized treatment. The yield of lettuce was 175% higher in solarized soil compared with untreated control. Based on these results, we suggest that solarization, which prevents chemical contamination and is suitable for organic farming, is an appropriate technology where the risk of nematode infestation is high in the second crop.

In cooperation with the Albanian Agriculture Competitiveness Project, on a workshop about the new technologies of nematode control (soil solarization) was organized on January 26, 2008 in Gorican (Berat).

Thirty-five participants (farmers, extension officers, and specialists of vegetable growing) from different villages attended the meeting. During technology transfer activity, participants were exposed to an overview of IPM and IPM CRSP activities and achievements in Albania, and the results to control nematode using the soil solarization method during the summer period. Another workshop was organized on February 2, 2008 in Kemishtaj (Lushnjë) and 16 farmers attended the presentations.

Based on this result, Eron gjipali, a specialist of AUT working under the direction of Josef Tedeschini (though not directly supported by CRSP funds), is preparing the thesis for a doctorate on integrated control of root-knot nematode in greenhouses.

Soil solarization should be done during the hottest period of the year. Soil solarization offers a satisfactory and environmentally friendly solution for the control of root-knot nematode. This method is easy to be used in organic, conventional, and integrated control growing systems.

**The efficacy of soil solarization and different nematicides used to control root-knot nematode (*Meloidogyne incognita*) on tomato in unheated plastic greenhouse in Albania**

V. Jovani, J. Tedeschini, A. Ramadhi, D. Pfeiffer

A field experiment was performed in clay soil, naturally infested with *Meloidogyne incognita* in the Lushnjë region, Albania, to assess the effectiveness of the combination of soil solarization with different liquid nematicides for control of root-knot nematode in tomato cv.19/12 compared with non-treated control. Soil solarization was performed over four weeks during the warmest month of summer in 2007. A 0.06mm polyethylene plastic film was used as soil covering. The soil temperature in solarized plots was $15^{\circ}$C higher than in the nonsolarized treatment. Maximum soil temperatures were recorded in solarized soil at $52^0$C at a depth of 20cm. Population densities of *M. incognita* were controlled by both soil solarization with Fenamiphos and soil solarization with Ethoprophos. At the harvest of tomatoes, the reduction of nematode population density was 100% and 98%, respectively. Both these treatments also increased yields, compared with the non- treated control. Tomato cv19/12 yield was 76 t/ha, 70 t/ha, and 37 t/ha, respectively, in combination of solarization plus Fenamiphos application, solarization plus Ethoprophos application, and untreated control. The incorporation of soil solarization into nematode management can lessen the environmental impact of these programs.

**Evaluation of bio-fungicide for control of powdery mildew of greenhouse cucumber**
J. Tedeschini, H. Paçe, D. Pfeiffer

A fungicide trial was established in a commercial Israeli type greenhouse at Durrës region in November 2007 to evaluate efficacy of several fungicides for control of powdery mildew (*Sphaerotheca fuliginea*) on cucumber. Treatments included the biofungicide Serenade (*Bacillus subtilis* QST13), UFO (ultra fine oil), Stopin 25WP (myclobutanil) and monopotassium phosphate salt applied as single treatments every 7- 10 days to each of five replicates. In samples to determine the percentage of leaf area affected by powdery mildew within different treatments, Serenade and Stopin were significantly different from non-treated control. Although UFO and phosphate salt were different from the control this treatments had more number of leaves infected than other treatments.

**Soil treatment with bionematicide and low dose of nematicides in controlling of root-knot nematode (*Meloidogyne* spp.) on tomato crop in unheated polyethylene house**
V. Jovani, J. Tedeschini, A.Ramadhi, D. Pfeiffer

The bionematicides Nemafung, Softguard and another product Fenamiphos liquid 40% at low dose 20kg/ha were applied to limit the damage of root-knot nematodes on tomato in an unheated polyethylene house in Kemishtaj (Lushnjë region).

The results revealed that the treatments were efficient in controlling the nematode. After the treatment with a low dose of fenamiphos 40% the reduction of the nematode population in the soil was about 96%. The reduction of nematode populations by Nemafung and Softguard was 76% and 65%, respectively. The treatments by drip irrigation suppressed also the root gall index on tomato crop. The root gall index before the treatments was 2 and at the final harvest was 0.2, 0.5 and 0.8 for fenamiphos at low dose of 20 kg/ha, Nemafung and Softguard, respectively. Regarding tomato yield, the highest yield was in the fenamiphos treatment followed by Nemafung and Softguard treatments.

**Soil treatment with bionematicides in controlling of root-knot nematode (*Meloidogyne* spp.) on cucumber crop in unheated polyethylene house**
V. Jovani, J. Tedeschini, A. Ramadhi, D. Pfeiffer

The bionematicides Nemafung, and Softguard were applied to limit the damage of root-knot on cucumber in an unheated polyethylene house in Kemishtaj (Lushnjë region). The results revealed that the treatments were efficient in controlling the nematode when the population densities before the treatment are not at high level. After the treatments with Nemafung, the level of the nematode population in the soil was not increased. The treatments by drip irrigation suppressed also the root gall index on cucumber crop. At the final harvest the root gall index was 0 for the both treatments. Regarding the cucumber production the highest yield was observed in the Nemafung treatment.

**Soil treatment with bionematicide and low dose of nematicides in controlling root-knot nematode (*Meloidogyne* spp.) on cucumber crop in unheated polyethylene house.**
V. Jovani, J. Tedeschini, A.Ramadhi, D. Pfeiffer

The bionematicides Nemafung, Softguard and another products fenamiphos liquid 40% at low dose 20kg/ha were applied to limit the damage of root-knot on cucumber in unheated polyethylene house in Goricaj (Lushnjë region).

The results revealed that the treatments were efficient in controlling the nematode. After the treatment with a low dose of fenamiphos 40% the reduction of the nematode population in the soil was high. The reduction of nematode populations for Nemafung and Softguard was 100% and 678%, respectively. The treatments by drip irrigation also suppressed the root gall index on tomato crop. The root gall index before the treatments was 2 and at the final harvest was 0, and 0.6 for fenamiphos at low dose of 10 kg/ha plus Nemafung and Softguard plus fenamiphos, respectively. Regarding the cucumber production the highest yield was in fenamiphos treatment plus Nemafung.

**Soil treatment with bionematicide and nematicides for the control of root-knot nematode (*Meloidogyne* spp.) on cucumber grown in Israeli-type greenhouses**

V. Jovani, J. Tedeschini, A.Ramadhi, D. Pfeiffer

The bionematicide BioNem (*Bacillus firmus*) and two other products, ethoprophos 19% liquid and fenamiphos liquid 40%, were applied to limit the damage of root-knot nematode on cucumber grown in Israeli-type greenhouses in Mullet (Tirana region).

The results revealed that the treatment by drip irrigation was effective in controlling the nematode. BioNem, ethoprophos 19% liquid, and fenamiphos 40% caused the reduction of the nematode population in the soil. The treatments by drip irrigation suppressed also the root gall index on cucumber crop. The root gall index at the final harvest was 1, 2, and 2.1 for fenamiphos, ethoprophos 19% liquid, and BioNem, respectively. Cucumber yield was 1229, 1187, and 1125 t/ha[1] in fenamiphos, ethoprophos, and BioNem treatments, respectively.

## Moldova

### Pest biology in tomatoes and cucumbers

Arthropod composition and phenology in vegetablefields was studied. In greenhouses, the efficacy of botanical pesticides for greenhouse whitefly, *Trialeurodes vaporariorum*, and twospotted spider mite, *Tetranychus urticae*, were evaluated. A new preparation based on Pyrethrum + Canola oil against whiteflies in greenhouses has shown promising results. Phenological models for management of *Helicoverpa armigera*, late blight, and downy mildew were tested in order to develop cultural control tactics for target pests.

### Disease management in tomatoes and cucumbers

Studies were carried out with powdery mildew on cucumbers and *Alternaria* on tomatoes. Mineral oil (summer oil), baking soda, extract from *Reynoutria sachalinensis* (giant knotweed), and bicarbonate were tested against powdery mildew on cucumbers in greenhouses and open fields.

## Ukraine – L'viv

### Use of biological soil amendments to enhance yield of cucumbers

Studies were conducted to introduce an integrated system of cucumber growing. Applications of chemicals were conducted from the third leaf stage to the budding stage.

Studies were also conducted to investigate the possibility of growing cucumbers organically. Half of the seeds of three varieties of cucumbers were treated by bacterial agents Agrophil (*Agrobacterium* sp.) and Flavobacterin (*Flavobacterium* sp.). No chemicals were applied. Yield varied depending on the variety and bacterial agent treatment. Plants treated with bacterial agents gave better yield and they started to yield sooner.

A comparison was made between production in greenhouses and in open soil using barnyard manure and no chemical pesticides with yields in the greenhouses averaging around 40 c/ha, and that in the open 35 c/ha.

## Ukraine – Odessa

Tests on an integrated system of plant protection were set up on the farms of August Ltd., and a workshop to disseminate the pest and pesticide management program (PPMP) of orchards and vineyards among farmers and peasants was organized.

An integrated system of grape protection was planned. Before establishing the vineyard in 2006, green manure (buckwheat plants) was used. Soil was prepared for planting using band planting to the depth of 60cm without turning the soil. A special plow was used for that, furrowing the soil and permitting access of air and water to the rhizoshpere of young vines. Before planting, vines were put into water with growth stimulators, humate of potassium, the biological agent Baikal (EM technologies), and the systemic insecticide Confidor (imidacloprid) for one-two days to stimulate better growth and root development. In addition, directly before planting the root system, seedlings were dipped into Teravet gel which helps to keep moisture around root systems for a long time, even in hot, dry weather. On the part of the seedling, a mechanical method of controlling soil insects was used – it is a sleeve of special film which is put into the stem of a seedling to protect it from the larvae of June beetles, and during two years, it ultimately dissolves in the soil (Figure 6).

Figure 6. Film sleeve placed around vines at time of planting.

**Ukraine – Dnipropetrovsk**

Field experiments were conducted to demonstrate biological protection techniques of tomatoes and cucumbers in the Dnipropetrovsk region. Treatments included "Trichodermin" - *Trichoderma lignorum*, "PentaPhag" - liquid culture, including the virions of the five strains of bacterial viruses and biologically active substances, "PlanRiz"– *Pseudomonas fluorescens* AP-33, "Bitoxibacillin" - liquid culture, including the bacteria *Bacillus thuringiensis var. thuringiensis*, and produced with bacteria proteins ($\theta$ *-endotoxin* and *-endotoxin*).

**Training and information exchange on participatory IPM.**
**Statistical/GIS Training**
Phenological models based on degree-day for main pests were tested. A workshop on statistics and GIS (use of BioClass GIS classification software) was carried out in Ukraine in the Nikolayev district (Mar 20-22, 2008). The results of research were demonstrated at the XII International scientific and technical Symposium: Geoinformation monitoring of environment: GIS and GPS Technologies (9-14 September 2008, Ukraine). (www.geocities.com/astralagt/index.htm).

**Language translation technology**
Technical presentations in multilingual Breeze are planned to complement general presentations online. A PowerPoint presentation on soil solarization work in Albania has been created and distributed to coordinators for translation into respective languages via the Eastern European IPM CRSP Scholar site.

**Albania**

**Cucumber scouting**
In collaboration with the Albanian Agriculture Competitiveness Project, meetings were organized in Gorican (Berat region) on March 28, 2008 and in Velmisht (Fieri region) on April 3, 2008 with participation of specialists, farmers, and extension officers. In those meetings, the main pests and diseases of tomato observed in greenhouses during monitoring were represented. Leaflets on white fly and leaf miner identification, biology, and management were developed and distributed.

**Tomato scouting**
In collaboration with the Albanian Agriculture Competitiveness Project, two meetings (Berat and Shkodra regions) were organized with participation of specialists, farmer,s and extension officers. In those meetings, the main pests and diseases of tomato observed in greenhouses during monitoring were represented. Leaflets on whitefly and leafminer identification, biology, and management were developed and distributed.

A poster was prepared and presented at the IPM CRSP 2008 Workshop that was heldMay 19-22 in Manila, Philippines.

**Whitefly control with botanicals**
A field workshop was held on September 23, 2008 at Kemishtaj (Lushnjë region), and was attended by agriculture technicians and farmers from Kemishtaj. Results of field studies on management of whiteflies on tomato crop during 2008 were presented and discussed.

A poster was prepared and approved for the IPMCRSP 2008 Workshop that was held May 19-22 in Manila, Philippines.

**Aphids**
A poster, "The monitoring of vegetable aphids," was prepared and presented in the Third-Meeting of the Institute Alba-Shkenca, Tirana that took place September 1-3, 2008.

**Spider mites**
In cooperation with the Albanian Agriculture Competitiveness Projec,t a workshop about new techniques and methods to control spider mites was

organized on May 22 in Kosmac (Shkodra region). This important activity attracted 25 farmers, technicians, and extension officers from three villages of the district of Shkodra, and served as an important vehicle for reporting IPM CRSP research and transferring IPM technology throughout the region.

**Fungicides for Botrytis**
The research was conducted with the involvement of one farmer group in the Lushnjë region. The IPM CRSP collaborators of AUT, in collaboration with the Albanian Agriculture Competitiveness Project, organized two training courses about the new control methods of tomatoes and cucumberd in greenhouses on March 23 (Gorican, Berati region) and May 22 (Kosmac, Shkoder region). Forty-two participants from different villages attended the courses. Several discussions occurred about integrated crop production in protected area and about the effect of pesticides used during the last years. The participants received the materials prepared for this purpose.

**Tomato grafting for corky root and root-knot nematodes**
Grafted tomatoes were distributed in several farms. The trials are underway in soil-less greenhouses in the Durres region and in heated Israeli greenhouses in the Tirana and Kruja regions.

**Nematicides for root knot nematodes in pepper**
The results were presented and discussed in several workshops organized in the main region (Fieri, Lushnjë, Berati, and Shkodra) of vegetable cultivation in greenhouses.

**Fungicides to maximize profits**
Direct and constant communication occurred among investigators, collaborating scientists, and farmers.

The results were discussed in several workshopsconducted in collaboration with the Albanian Agriculture Competiveness Project in the main region of greenhouse areas.

**Solarization for soil-borne fungi**
Direct and constant communication occurred between co-principal investigators and collaborating scientists and farmers.

A poster was prepared and presented at the IPMCRSP 2008 Workshop held May 19-22 in Manila, Philippines.

**Solarization for root-knot nematodes**
Direct and constant communication between co-principal investigators and collaborating scientists and farmers occurred. Activities about the possibility of using the IPM package to control root-knot nematode in greenhouses were organized in the main regions of vegetable production in greenhouses (Lushnjë, Berati regions). In cooperation with the Albanian Agriculture Competitiveness Project, a workshop about the new technologies of nematode control (soil solarization) was organized on January 26, 2008 in Gorican (Berat). Thirty-five participants (farmers, extension officers, and specialists of vegetable growing) from different villages attended the meeting. During technology transfer activity, participants were exposed to an overview of IPM and IPM CRSP activities and achievements in Albania, and about the results to control nematode using the soil solarization method during the summer period. Another workshop was organized on February 2 in Kemishtaj (Lushnjë) and 16 farmers attended the presentations.

A poster was prepared and presented at the IPMCRSP 2008 Workshop held May 19-22 in Manila, Philippines.

**Solarization with nematicides for root-knot nematodes**
A local workshop, in collaboration with the Albanian Agriculture Competitiveness Projec,t was organized in Velmisht (Fieri region) on February 9, 2008. Three presentations about the new techniques of nematode control, the benefits of soil solarisation, etc., were prepared by the specialists of our project. Twenty farmers and vegetable producers from different villages attended the meeting. The workshop has been supplemented with printed materials.

**Partnering with NGO:** In order to improve our activity, expand the capacity of scientists to cooperate in IPM research and information dissemination, collaboration was established between NGO ProBio, NGO Ecosfera, and the Institute of Plant Protection and Ecological Agriculture.

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

*Wondi Mersie, Virginia State University*

**Host Countries:** Botswana, Ethiopia, Kenya, South Africa, Uganda
**Collaborators:** Ethiopian Institute of Agricultural Research; Plant Protection Research Institute, South Africa, Haramaya University; Makerere University, Kenya

**Distribution and spread of parthenium in eastern and southern Africa**

The potential distribution of parthenium in southern and eastern Africa was modeled in 2007 using the CLIMEX (ver.2) program. Outputs generated from the model were based on discrete weather station data from the region. Although useful, the outputs had large areas for which there was no available weather station data (especially for east African countries), and hence the predictive power of the model was limited. In 2007, the model was re-run using grid-based climate data to overcome the 'holes' in the 2006 predictive outputs.

**Methods**

The potential distribution of parthenium in southern and eastern Africa was modeled in 2006 using the CLIMEX (ver.2) program. CLIMEX model parameters were obtained from the Queensland Department of Natural Resources and Mines (QDNR&M). These parameters were developed using known thermal characteristics of parthenium (from the literature) and mapped distributions of the weed in its native range. The parameters were entered into a new species template in the CLIMEX program and the model was run. In 2006, predictive maps for southern and eastern Africa were generated. The maps depicted the Ecoclimatic Index (EI) -- i.e. an index showing the climatic suitability of a particular area for the favourable growth of *P. Hysterophorus*. These maps were used to assist in the formulation of the 2006 survey strategy for South Africa, Swaziland, Botswana, Uganda, and Ethiopia. Outputs generated from the model were based on discrete weather station data from the region. Although useful, the outputs had large areas for which there was no available weather station data (especially east African countries), and hence the power of the model's predictions was limited. To improve the predictive power of these outputs, and enhance the survey strategies, the model was modified in 2007 and re-run using grid-based climate data.

During 2005/2006, baseline distributions of parthenium were established for South Africa and Swaziland. South African baseline data was sourced primarily from the South African Plant Invaders Atlas (SAPIA), while the data for Swaziland came from their national plant database: (http://www.kbraunweb.com/alienplants/speciesinfo.asp).

Baseline records were captured. A road survey was conducted in 2006 and 2007 in South Africa, Swaziland, and Ethiopia to determine whether parthenium occurs in the quarter degree squares (QDS) immediately surrounding the known localities (including baseline and 2006 records). During roadside surveys, baseline distribution records were verified and new localities were recorded for each country involved. 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/$m^2$). Due to the absence of any baseline distribution data for parthenium in Botswana and Uganda, surveys were conducted along country border posts and major points of entry. Records from survey participants were corrected, formatted, and entered into a distribution database. Locality data were plotted using the program MapViewer (ver. 7.0). Maps of abundance of parthenium in Ethiopia and southern Africa were also generated from 2006 and 2007 survey data. Distribution survey data were compared with the CLIMEX predictions for validation of models.

**Results**

CLIMEX model outputs offered clearer, more complete predictions of parthenium in Africa using the grid-based climate dataset compared to the standard, discrete weather station dataset that was used initially. Not only did the predictive maps not have as many 'holes', but they also more closely matched the known distributions of parthenium.

The ecoclimatic indices calculated by the model serve to highlight areas that are climatically highly suitable for its growth and spread (although the weed may not yet be present in some of these areas) (Figure 1). Predictions indicated there were areas in Ethiopia, Kenya, Somalia, Tanzania, and Uganda that were ecoclimatically suitable for the favorable growth of *P. Hysterophorus* (Figure 1). For southern Africa, the CLIMEX model predicted that areas most suitable for the favorable growth of the weed were found in South Africa, Swaziland, the south of Madagascar, and Mozambique. In descending order, Zimbabwe, Botswana, and Namibia were shown to be relatively less suitable for the favorable growth of parthenium.

**Distribution Surveys**

Distribution data from all survey participants were assimilated into a combined database for Ethiopia and southern Africa. The database allows access to locality data including parthenium densities and land types invaded. Mapping using the GIS program MapViewer (ver. 7) was performed for baseline, year one, and year two survey data.

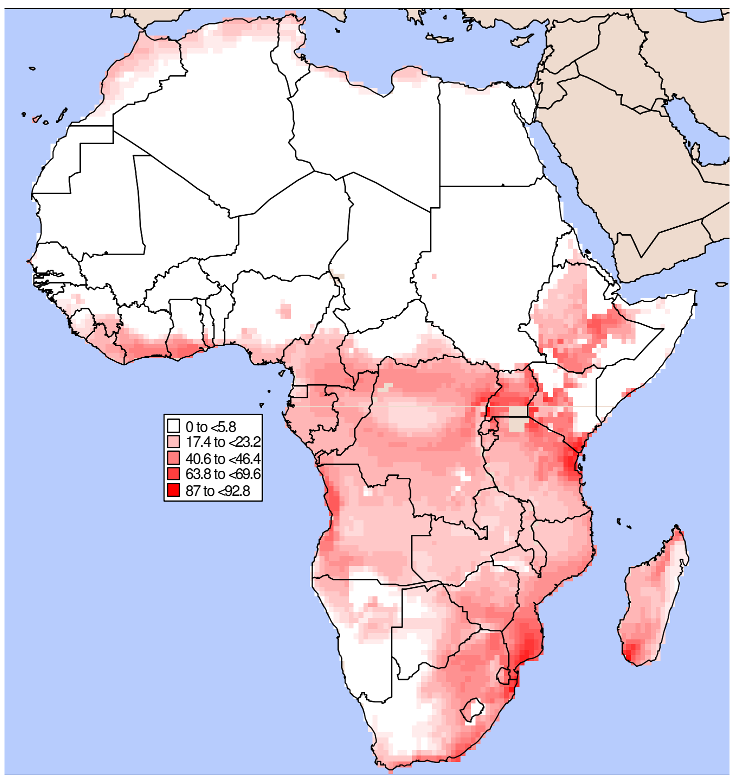



Figure 1: CLIMEX generated map of the relative climatic suitability of Africa for *Parthenium hysterophorus*. Colors (ecoclimatic index) depict the suitability of each location (the darker the shade of red, the more suitable the area for parthenium).

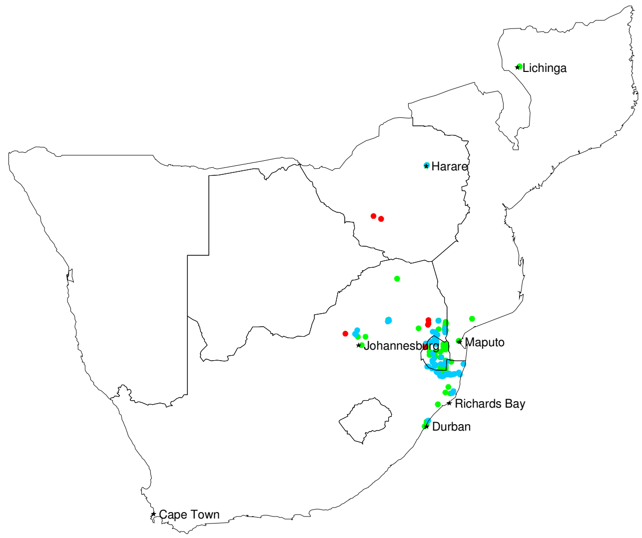



Figure 2: Distribution map of *Parthenium hysterophorus* in South Africa, Swaziland and part of Mozambique, with previously known records from SAPIA and Swaziland Alien Plant Database (green dots) and distribution records from 2006 survey (blue dots) and 2007 survey (red dots).

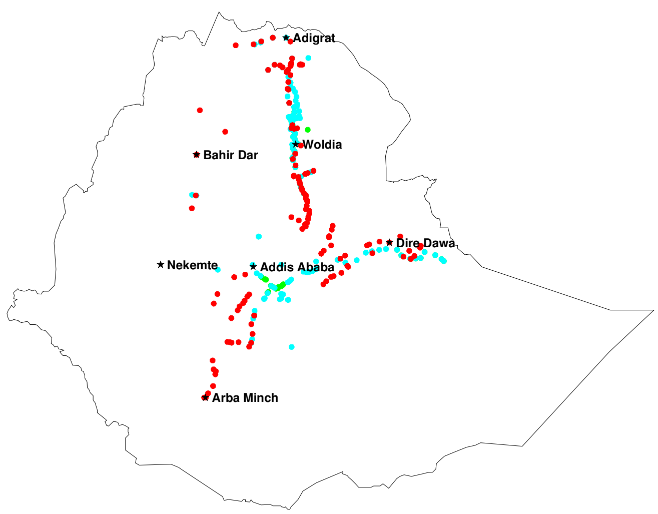



Figure 3: Distribution map of *Parthenium hysterophorus* in Ethiopia, with previously known records (green dots) and distribution records from 2006 survey (blue dots) and 2007 survey (red dots).

Surveys in 2006 and 2007 revealed a substantial increase in the known records for South Africa, Swaziland, and Ethiopia (Figures 2 and 3). This increase in the known number of parthenium localities is attributed largely to an increase in sampling effort (rather than spread of the weed). The impact of this survey included the realization of parthenium as a problem of national significance for Swaziland, and parthenium as a regional problem within the southern and eastern African regions. Parthenium was not detected in the areas that were surveyed in Botswana and Uganda. The significant reduction in new localities recorded during the 2007 survey in South Africa compared to the 2006 survey suggests that the current range of parthenium in South Africa may have been realized (Figure 2). The distribution of parthenium in South Africa currently occurs along the eastern parts of the Kwa Zulu-Natal province, extending into the north-eastern and western reaches of the Mpumalanga province, and north-eastern parts of the North West province (Figure 2). In Swaziland, the weed occurs in almost every quarter degree square throughout the country. In Ethiopia, parthenium was widespread in the north, east and south-western regions surveyed (Figure 3). The extent of distribution was much more widespread than previously recorded. Further distribution surveys should still be conducted in the eastern, southern, and south-eastern regions as these regions are predicted to be highly climatically suitable for parthenium (Figure 5).

The distribution of parthenium determined from road surveys and previous records was visually compared to CLIMEX outputs to validate predictions for southern Africa and Ethiopia (Figures 4 and 5).

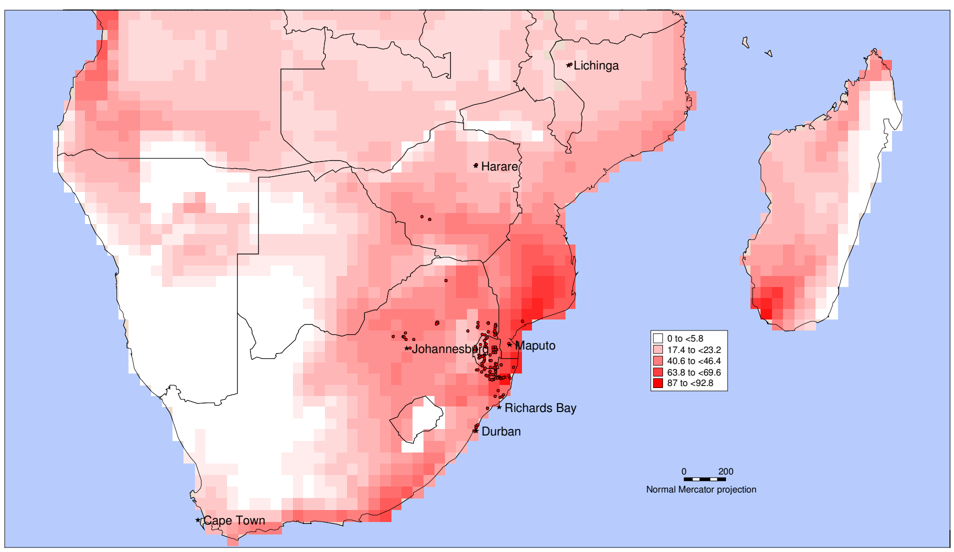



Figure 4: Distribution map of *Parthenium hysterophorus* in southern Africa overlaid on CLIMEX prediction for this region.

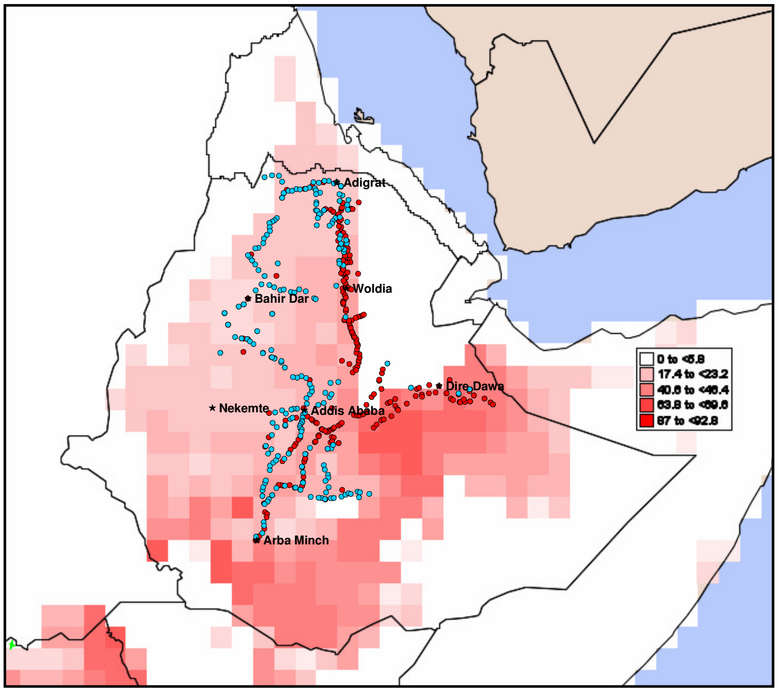



Figure 5: Distribution map of *Parthenium hysterophorus* in Ethiopia showing presence (red circles) and absence (blue circles), overlaid on CLIMEX predictions for this region.

Actual distributions of parthenium in southern Africa and Ethiopia concurred with the CLIMEX predictions as parthenium occurred in areas that were determined to be climatically suitable by the model (Figures 4 and 5), therefore validating the modelled predictions. There are additional areas that are highly climatically suitable for parthenium in Ethiopia and southern Africa, and more widely in the sub-Saharan region, and these should be monitored for occurrence of the weed.

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 since, prior to this, very little information was available for the distribution of parthenium in Africa; (ii) it provided baseline data to monitor the 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.

**Assessment of socio-economic impact of parthenium in Ethiopia**

A study on farmers' and agro-pastoralists' perception on effects of parthenium was conducted in the districts of Babilie, Haramaya, and Tulu (Hirna). It was noted that considerable proportions of the farmers were aware of parthenium weed with respect to the time of introduction, means and source of introduction, and problems caused by the weed. They emphasized that parthenium grows throughout the year and its spread is increasing. These farmers perceived that around 12 different plant species in Babile, 10 different plant species in Haramaya, and eight different plant species in Tulo were identified to be critically endangered by parthenium weed.

The invasion of parthenium weed causes loss of income to farmers. It has been estimated that yield loss of sorghum due to parthenium translates to a 43.4%, 68.7%, and 69.7% reduction of farmers' income in Babile, Haramaya, and Tulo district, respectively, during the 2007/2008 production year. Apart from the adverse effects of parthenium on crop yields, it has a direct impact on livestock production as it reduces feed availability. Parthenium also affects the taste and aroma of milk, and quality of meat.

**Effect of Parthenium on plant diversity**

The effect of varying parthenium densities on herbaceous species diversity and soil seed bank in grazing lands and sorghum fields were investigated in eastern Amhara, Ethiopia. The specific objectives of the study were to study the impact of parthenium on herbaceous plant composition and diversity, determine spatial abundance of parthenium in soil seed bank flora compared to the other herbaceous species, and to relate soil seed bank flora with the composition of the standing vegetation. The study included three levels of parthenium infestation: low (0-25%), moderate (26-50%), and high (> 50%) of total area covered with parthenium weed. These infestation levels were established by visual observation from 180 sampling spots using randomly thrown quadrates measuring 1m x 1m.

This study demonstrated that parthenium is affecting the biodiversity with percent importance values of 20.6, 46.4, and 69.7 in low, moderate, and high infested sorghum fields, respectively. Similarly, in grazing areas, parthenium showed 15.7, 64.4, and 84.2 percent importance values in low, moderate, and high infested sites, respectively. The average seedling density over all infestation levels indicated that parthenium accounted for 64% and 59% of the total seedlings germinated from the soil seed bank samples taken from sorghum fields and grazing lands, respectively. Species diversity and evenness declined with the increasing density of parthenium in the standing vegetation and soil seed bank flora both in sorghum fields and grazing lands.

This study further revealed that parthenium was found to be the most dominant weed in sorghum fields with 12%, 31%, and 59% of cover abundance in low, moderate, and high infestation levels, respectively. Weed species diversity and evenness in low parthenium infested sorghum fields were much higher than in the site where parthenium infestation level was high. The regression analysis indicated that there was a highly significant and negative association between weed species diversity and evenness, with percent parthenium coverage, with $r^2$=79.5% and $r^2$=61.4%, respectively.

Similarly, weed species diversity and evenness in the soil seed bank significantly declined as parthenium cover increased. There was a 56.6% decline in the diversity index in high parthenium-infested fields as compared to low-infested fields. Likewise, the evenness index was relatively higher in low infested areas, indicating the weed species were more equitably distributed at this site than the other sites. Owing to its high invasive nature and allelopathic effect, parthenium seems to displace the indigenous weed species and pose a serious threat to the environment and biodiversity of the study area.

In grazing lands, parthenium was found to be the most dominant weed with 8, 36, and 56% cover abundance in low, moderate, and high infested sites, respectively. This weed also had the highest percent importance value in all infestation levels. The regression analysis indicated that there was a highly significant and negative association between species diversity and evenness with increasing parthenium coverage. Similarly, species diversity and evenness in the soil seed bank significantly declined as parthenium cover abundance increased, with $r^2$=90.6% and $r^2$=87.8%, respectively. This study verified that parthenium is aggressively colonizing the study area.

A soil seed bank study is also being conducted in the northern region of Ethiopia by Mekelle University. Soil samples were taken at a depth of 10cm from disturbed and undisturbed fields in the Alamata district, which is located in the southern part of the Tigray Region. The germination of parthenium and other weed species in the soil samples is being counted every week.

**Conclusions**

This study showed that *Parthenium hysterophorus* has been influencing the composition and diversity of species both in aboveground vegetation and soil seed bank. It also showed that the weed weakens the carrying capacity of pastures, reducing livestock productivity. The study reveals the difficulty of controlling parthenium in a short period of time due to persistent seed reserve in the soil and wider area coverage. Thus, well organized, coordinated, and concerted efforts must be made to control or eliminate the weed. It requires the participation of local people, scientists, governments, and NGO's to work hand in hand.

**Evaluate and release biocontrol agents for the control of parthenium in South Africa and Ethiopia**

The aim of this objective is to evaluate the host range of selected insect species as biocontrol agents for the control of parthenium. Nine insect agents and two rust fungi have been released and established successfully on parthenium in Australia (Dhileepan & McFadyen, 1997; McFadyen, 2000). The agents that have been selected for South African conditions are the stem-boring weevil *Listronotus setosipennis* (Coleoptera: Curculionidae) and leaf-feeding beetle *Zygogramma bicolorata* (Coleoptera: Chrysomelidae) which are currently being investigated, and once testing has been completed on these, the stem-galling moth *Epiblema strenuana* (Lepidoptera: Tortricidae) will be imported for evaluation. *Listronotus setosipennis* is considered suitable for seasonally dry regions such as those that occur in South Africa. *Zygogramma bicolorata* and *E. strenuana* have been shown to be highly effective in Australia.

*Listronotus setosipennis*, originating from Argentina, is a nocturnal weevil that feeds and deposits frass-covered eggs singly on flowers and stems. Larvae tunnel in stems to the plant base, where they exit the stem to pupate in the soil, eclosing from the soil as adults. The complete life cycle is approximately five weeks. *Zygogramma bicolorata* imported from Australia, but originally collected from Mexico, feeds on leaves and flowers. Eggs are deposited in small clusters on leaves, and larvae feed on leaves and buds. Mature larvae enter the soil and pupate within chambers, with adults then eclosing from the soil. The life cycle is approximately six to eight weeks. High humidity and available moisture are essential to ensure continuous oviposition by *Z. bicolorata* and avoid adult diapause in the soil.

Extensive host range testing has been conducted in Australia and India on selected biocontrol insect agents for parthenium. No-choice tests (where insects are given no alternative host plant) are being used to narrow the range of plants that are suitable for agent oviposition, feeding, or development. Each plant species is replicated three times, and variables such as oviposition, feeding, development, and/or 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 to the larval and adult stage is being used initially as a measure of host suitability, and for *Z. bicolorata*, adult feeding and oviposition is used as an indicator of host suitability in no-choice tests. No-choice tests will be used to examine *L. setosipennis* oviposition. Choice tests on selected species that *Z. bicolorata* fed/oviposited on during previous no-choice tests, will be conducted to further examine the host range of *Z. bicolorata*.

**Host range testing of *L. setosipennis* and *Z. bicolorata* in Ethiopia**

In Ethiopia, the research activities were focused on screening of different cultivated crop plants and indigenous weed species against the introduced biological control agent *(Zygogramma biocolorata)* through no-choice and choice tests under quarantined conditions at Ambo. Establishment of test plant nurseries, and maintenance and mass-rearing of *Z. biocolorata*, were the major activities involved in the test. The quarantine facility was also visited by different researchers, higher officials, and interested groups at various times of the year.

**Host range testing of *L. setosipennis* and *Z. bicolorata* in South Africa**

**Rearing of biocontrol agents**

About 500 parthenium stock plants, as well as selected test plant species of commercial, indigenous, and ornamental origin for use in host range tests, were propagated and maintained on a continual basis during the reporting period. Information on source localities of several obscure indigenous species was obtained, and several species were obtained. Cultures of *Z. Bicolorata* (Coleoptera: Chrysomelidae) and *L. Setosipennis* (Coleoptera: Curculionidae) were maintained in the quarantine laboratory during the reporting period. Routine maintenance of insect cultures was conducted on a daily basis, providing cultures with a clean environment and sufficient plants for food and oviposition.

**Host range testing of biocontrol agents**

Further no-choice host range tests were continued during the reporting period for *L. Setosipennis* and *Z. Bicolorata*.

Plant species and varieties that are unique and relevant to South Africa and governing authorities are being tested.

As *L. Setosipennis* covers eggs with frass, it is difficult to differentiate them from frass alone without destructive sampling; therefore, plants from no-choice tests are left for six weeks after exposure to *L. Setosipennis* adults, before being dissected to check for development of larvae, pupae, or adult progeny. No larvae and/or adults developed in any of the replicates of the 19 non-target species (and several varieties of some species) tested so far, except on one replicate of *Blainvillea gayana* where one larva (about third instar) was found and parthenium controls where numerous larval and adult progeny were produced. Further tests on these and other related species are continuing. No testing is conducted during the winter season when insects are less active and plants are not actively growing. Tests on *G. Abyssinica* varieties for Ethiopia will be repeated as soon as plants are mature and flower, sinceplants did not stay in good condition during the trial in previous laboratory conditions.

In a preliminary trial that was conducted to determine optimal methods to examine *L. Setosipennis* oviposition, eggs were laid on several of five varieties of sunflowers, particularly PAN 7050 and PAN 7033, after five days of exposure by

10 adults to the plants. Further detailed oviposition tests will be conducted on these and other sunflower varieties as well as on other species. However, the incidence of *L. Setosipennis* eggs on sunflowers is not totally unexpected as that *L. Setosipennis* oviposited on sunflower varieties in tests conducted in Brazil and Australia, although oviposition was less than 1% of that on parthenium and less than 2% of those eggs survived to adults.

Thus far, *Z. bicolorata* has been tested on 38 indigenous, exotic, and economically important species (including 14 varieties of sunflowers) that are closely related to parthenium in South Africa. Feeding has been recorded on 12 of these species and oviposition on 13. In all cases, the relative amounts of feeding/oviposition were significantly less than that recorded on *P. hysterophorus*. All of these species will now be included in extensive multiple-choice trials to further examine the host range of *Z. bicolorata*. It is envisaged that these trials will be concluded by the end of the 2007/2008 summer season.

Initially, about 531 adults and 300 larvae individuals were imported from South Africa. Currently, the average numbers of the bio-agent available are estimated to be more than 1153 adults and 708 larvae after removing individual test insects.

**Biocontrol pre-release studies**

In preparation for the future, when the impact of approved, released, and established biocontrol agents can be assessed in the field, trials were continued during the reporting period to obtain baseline data on the extent of parthenium soil seed banks and relative composition of other plant species within parthenium.

**Methods:**

In April 2006, at the end of the summer growing season, three sites with large, dense parthenium infestations were selected within an area of national conservation significance: Kruger National Park (Mpumalanga Province of South Africa). These sites were sampled again in March 2007 and April 2008 towards the end of the growing season. In 2007, a similar study was initiated within the Pongola Game Reserve in the KwaZulu-Natal Province, near the epicentre of dense parthenium infestations in southern Africa, and three sites were sampled. In 2008, due to resource constraints (space for seedling trial and staff capacity), only two of the three sites were sampled at Kruger NP and two sites at Pongola GR. The same 35-40m$^2$ plots within the dense infestation of parthenium were sampled at each site each year, and 20 quadrats of 0.5x0.5m = 0.25m$^2$ were randomly selected within each plot. The number of mature parthenium plants within each quadrat was recorded as a measure of plant density. Using a soil corer (7cm diameter x 6cm 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.

At PPRI Cedara research station, a 5cm layer of sterilised potting soil was placed in each of 60 seedling trays (30cm x 27cm x 11cm) per study area (20 samples per site, and 20 samples as a control). Each field soil sample was then spread onto the sterilised potting soil per 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 before termination. 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 the flowering stage. Herbarium specimens of the other species were then pressed for identification. These trials are being conducted annually in order to assess parthenium soil seed banks at these sites and ultimately quantify the impact of biocontrol agents on parthenium soil seed banks at these sites.

The Skukuza site has a higher percentage of sand in the soil composition than the Crocodile Bridge site, which has more clay and silt by comparison.

This is a long-term study and data are still being collected for analysis. The number of mature *P. hysterophorus* plants per m$^2$ at the end of the growing season at sites in Kruger National Park in 2007 and 2008 was substantially lower than in 2006. Similarly, the number of seedlings that germinated from Kruger National Park soil in a temperature-controlled tunnel at ARC-PPRI, Cedara in 2007 and 2008 was much less than in 2006. *Parthenium hysterophorus* is an annual plant and the large variation in numbers of seeds available for germination in the soil seed bank is likely attributed to varying rainfall. Rainfall data still need to be correlated with seed bank data. The Skukuza old dump site had the highest density of parthenium seedlings per m$^2$ that germinated from the soil seed bank in 2006, 2007, and 2008, even though the other sites also have dense infestations of the weed.

Pongola Game Reserve had a higher mature plant density and number of seedlings in the soil seed bank than Kruger NP, probably since it is closer to the epicenter of the original introduction sites and has denser infestations. Additionally, the Pongola sites are situated on the banks of a dam, so plants are not as moisture-limited as those in Kruger.

Forty-one broadleaf and grass species that germinated from the soil seed bank from sites in Kruger National Park in 2008 are still in the process of being identified. Approximately 41 broadleaf species and 20 grass species germinated from the Kruger National Park soil seed bank in 2006 and 36 grass and broadleaf species germinated in 2007.

Despite lower rainfall and a smaller seed bank of available parthenium seeds than in the first year of the study, results from the 2008 sampling and experiments still indicate that there are thousands of viable parthenium seeds in the soil, indicating the huge potential that parthenium has to increase the density of current infestations as well as to spread. All sites have dense infestations of *P. hysterophorus*.

These data are most beneficial in providing a baseline of the 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. Additionally, information on the population dynamics of infestations is being obtained. It is expected that *L. Setosipennis* and *Z. Bicolorata* will have an impact on the 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 the spread of the weed.

**Evaluation and demonstration of pasture management systems for the control of parthenium.**

Continue the field trials to determine effective pasture management systems against parthenium at Jijiga, in eastern and northern Ethiopia**.**

A competition study in parthenium-infested pasture fields has been conducted since August 2006. Experimental plots were established using grass and legume species adapted to Somali rangelands. However, due to unpredictable circumstances, the experiments failed two times. The same trial is now being conducted as the Somali Pastoral and Agro Pastoral Research site, some 30Km east of Jijiga by Haramaya University, and in the Alamata district in southern Tigray by Mekelle University. The experiments were established in the first week of August 2008 at both locations. Six different forage crops, namely *Cenchrus ciliaris, Panicum coloratum, Sorghum sudanese, Vicia dasycarpa, Clitoria ternata,* and *Stylosanthes hamata*, were oversown on burned and mowed strips in four replications. The vegetation composition of the site was also recorded before planting. Rain started two weeks after sowing in Alamata while there was no rain in Jijiga for over three weeks. During the planting of at Alamata, forage and livestock production experts from the Alamata District Agriculture and Rural Development Office participated.

**Extension and training**

The weed biocontrol quarantine facility at the EIAR Plant Protection Research Center, Ambo was opened on October 16, 2007. Several partners gave presentations on weed biocontrol and on the biology of the leaf-feeding beetle *Z. bicolorata*, on the distribution of parthenium in the world, about the quarantine facility at Ambo, and the adverse impact of the weed on food security to guests. The guests came from Virginia State University, EIAR, the Ministry of Agriculture, zonal and regional representatives from the surrounding area, and from the Ethiopian media. Mass-reared *Zygogramma bicolorata* in South Africa was supplied as a starter colony (550 adults and 750 larvae) to EIAR, Ambo quarantine research laboratory.

This ceremony was significant in that it was the first formal introduction of a parthenium weed biocontrol agent into Ethiopia for further host range research in quarantine on relevant plant species in Ethiopia. The urvival rate of the introduced adult and larva of the beetle was high (approx. 90%), and the various life stages were placed onto plants within cages in the quarantine facility.

South African partners assisted EIAR entomologists in setting up the culture of *Z. bicolorata* in quarantine at Ambo and trained them in handling and culturing the agent. Technical advice to EIAR staff and troubleshooting problems with rearing and testing of *Z. bicolorata* was also provided. Partners also developed guidelines/protocols for quarantine procedures for EIAR.

Dr. Mulugeta Negeri (senior entomologist), Mr. Abebe Megersa (MSc researcher), and Mr. Asegid Wegayehu (laboratory technician) were assisted and trained in the handling and culturing of *Z. bicolorata* as well as weed biocontrol quarantine protocols. In a few days after introduction, larval and adult feeding and oviposition were observed, indicating that quarantine conditions were appropriate for their maintenance.

The Biological Control Facility at Ambo Plant Protection Research Center (PPRC) was also visited Ethiopian government officials from the ministry of agriculture and the Ethiopian Institute of Agricultural Research (EIAR), and researchers of PPRC visited. There were a total of 45 visitors, and on July 9, 2008 by Virginia State University guests, six of whome were women. The event attracted the attention of the national media, and was reported by the national newspaper (Addis Zemen), national radio, and television.

# International Plant Diagnostic Network (IPDN)
## Regional Diagnostics Laboratories

*Sally Miller, Ohio State University*

**Co-Investigators**
Sue Tolin, Virginia Tech
Carrie Harmon, University of Florida
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**Host Country Regions:** Caribbean, East Africa, West Africa
**Collaborators:** IITA; AVRDC; USDA/APHIS; Agroexpertos, Guatemala; Kenyan Agricultural Research Institute; West Africa Regional Program; East Africa Regional Program; Latin America and the Caribbean Regional Program; Eastern Europe Regional Program; Insect Transmitted Viruses Global Theme

**Strengthening ties within regional hub and spoke laboratories by completing formal agreements with designated spoke laboratories**
The following laboratories have indicated interest in participating in the IPDN – East Africa site. Zambia is not currently part of the IPDN; however, representatives of Zambian diagnostic laboratories have attended our training programs with the support of the USAID/USDA FAS (APHIS), under the auspices of the East African Phytosanitary Information Committee (EAPIC). Zambia will be considered for inclusion in the IPDN network if additional funding becomes available. Likewise, Nigeria is not formally a member of the IPDN, but is included in the list because the leadership of the West Africa site is centered in IITA, with labs in both Benin and Nigeria. Formal agreements with the institutes/universities housing the spoke laboratories are in progress. Formal agreements with institutions in Central America are in place.

A meeting with plant pathologists and entomologists from several Ghanaian universities and research institutes, IITA, USDA/APHIS/USAID West Africa, and S.A. Miller (IPDN) was held at the University of Ghana, Legon on April 14, 2008 to introduce the IPDN and explore interest in participation amongst Ghanaian institutions. Twelve Ghanaian participants described their own programs, completed a survey on diagnostic capacity in their labs, and participated in the general discussion. The outcome was a list of eight university and government laboratories in Ghana included in the IPDN.

| Lab Name – EAST AFRICA IPDN | City | Province | Country |
|---|---|---|---|
| KARI Plant Pathology Section (HUB) | Nairobi | Nairobi | Kenya |
| Mycology Lab-School of Biological Sciences | Nairobi | Nairobi | Kenya |
| Namalere Phytosanitary & Diagnostic Laboratory | Entebbe | | Uganda |
| Biotechnology laboratory, Faculty of Agriculture | Kampala | | Uganda |
| Plant Protection Section, PQPD | Lusaka | Lusaka | Zambia |
| Plant Protection Section | | Mbeya | Tanzania |
| Kawanda Plant Pathology | Kampala | Kampala | Uganda |
| KARI-NARL Postharvest Entomology Lab | Nairobi | Nairobi | Kenya |
| Pathology lab | Nairobi | Nairobi | Kenya |
| Post-entry Lab-TPRI | Arusha | Arusha | Tanzania |
| National Bean Pathology Lab | Kampala | Kampala | Uganda |
| Entomology | Nairobi | Nairobi | Kenya |
| Entomology | Morogoro | Morogoro | Tanzania |
| KARI-NARL Field Entomology Lab | Nairobi | Nairobi | Kenya |
| ZARI Entomology Lab | Lusaka | Lusaka | Zambia |
| ZARI Quarantine Lab | Lusaka | Lusaka | Zambia |
| ISAR Plant Pathology Lab | Musanze | Northern | Rwanda |

| Lab Name –WEST AFRICA IPDN | City | Country |
|---|---|---|
| Plant Health –IITA (HUB) | Cotonou | Benin |
| Plant Health-IITA | Ibadan | Nigeria |
| Plant Quarantine | Ibadan | Nigeria |
| Plant Health-AVRDC | Bamako | Mali |
| Plant Health-IITA | Kampala | Uganda |
| Univ. de Thies | Thies | Senegal |
| Oil Palm Research Institute | Kusi | Ghana |
| Cocoa Research Institute | Tafo | Ghana |
| Univ. Ghana-Legon | Legon | Ghana |
| PPRSD | Accra | Ghana |
| Univ. Ghana-Kpong | Kpong | Ghana |
| Univ. Cape Coast | Cape Coast | Ghana |
| Crops Res. Institute | Kumasi | Ghana |
| Kwame Nkrumah Univ. Science and Technology | Kumasi | Ghana |

| Lab Name – Central America Site | City | Country |
|---|---|---|
| Agroexpertos (HUB) | Guatemala | Guatemala |
| Laboratorio de parasitologia Vegetal CENTA-MAG | San Andres | El Salvador |
| FHIA-Depto.Proteccion Vegetal | San Pedro Sula | Honduras |
| Ministry of Agriculture Diagnostic laboratories | Old Harbour | Jamaica |
| Laboratorio Fitopatologia Universidad Rafael Landivar | Guatemala | Guatemala |
| Centro de Diagnostico Parasitologico de la Facultad de Agronomia, Universidad de San Carlos de Guatemala | Guatemala | Guatemala |
| Laboratorio Fitopatologia Universidad Del Valle de Guatemala | Guatemala | Guatemala |
| Laboratorio de Fitoproteccion Zamorano | Tegucigalpa | Honduras |

**Possible expansion of Central America Site**

At the request of the Government of Ecuador through its agricultural research organization (INIAP), an IPDN team (S.A. Miller, OSU; C.L. Harmon, UF; M. Arevalo, Agroexpertos) traveled to Ecuador from February 11-15, 2008 to assess the capacity of four laboratories within the INIAP system for plant disease and pest diagnostic capacity. The team traveled to INIAP laboratories in Pichilingue, Portoviejo and Santa Catalina. A report on the Boliche station was prepared by another team member (J. Mera, OSU) in December 2007 and was considered in the assessment and recommendations. The team also met with representatives of the USAID Ecuador Mission and USDA/APHIS and FAS, and in a separate meeting with representatives of INIAP and SESA at the Ministry of Agriculture in Quito. The consultation was organized by Dr. Carmen Suarez, and was funded by INIAP (primary), IPM CRSP South and Central America regional program, and the Diagnostics Global Theme.

INIAP is considering establishing a network of plant diagnostic laboratories in two phases. In Phase I, selected INIAP laboratories (Pichilingue, Santa Catalina, Boliche, Portoviejo) may be linked together, with laboratories at Pichilingue and Santa Catalina serving as organizing or hub laboratories. Phase II may involve building relationships and networking within the region and internationally within the framework of IPDN. Current projects and those that will be started in the near term (Phase I) include purchase and upgrade of laboratory equipment, facilities (buildings) and connectivity (broadband internet), a baseline survey of agricultural pests of the most important export crops, and training for diagnostic personnel. All of the stations visited carried out diagnostic services, with a greater number of plant disease than arthropod diagnoses. Each station is staffed with one or more pathologists and entomologists, some of whom have laboratory assistants. The diagnostic laboratory services are generally done as add-ons to the regular workload. An exception is the Santa Catalina station, which receives and diagnoses a large number of samples, and employs a full time diagnostic technician. None of the laboratories carry out arthropod, fungal, bacterial, or nematode diagnoses beyond the genus level, and only basic identification methodology is used. Serological assays for virus diagnostics are conducted at Santa Catalina, and molecular technology such as PCR is not used in any of the stations. Broadband internet connectivity is not available at all of the stations, and critical reference materials are outdated and in short supply. Scientific and technical staff members are in need of basic and advanced diagnostic training in arthropod and pathogen identification.

Recommendations were provided for improvements in facilities, equipment, procurement of supplies and reference materials, training, and networking in a separate report. Some recommendations vary depending on the station and its designation as a hub lab (Pichilingue and Santa Catalina) or satellite lab (Portoviejo and Boliche). The hub labs should be equipped for advanced serological and molecular diagnostics, while all labs should increase capacity for basic disease and pest diagnostics through facility renovations, equipment upgrades, purchase of supplies and reference materials, and staff training. The labs should be networked with each other and increase communication and data sharing. During Phase I, the IPDN CIMS/DDIS software should be evaluated. It should then be adopted during Phase II if it meets the needs of the stations. An extensive baseline survey of pests and pathogens of important export crops must be done as soon as possible in order to identify organisms of SPS priority. A significant investment in staff training should also be made to improve the quality of pest and pathogen identification and disease diagnosis. Additional efforts should be made to cooperate with SESA in SPS matters, including development of standard operating protocols for pest and pathogen identification and pest risk assessments.

**Priority lists of diseases and pathogens of important crops**

During the second IPDN Diagnostic Workshop held in Guatemala in July 2008, the bacterium *Ralstonia solanacearum* was voted the most important plant pathogen (bacterial wilt). This is mainly due to the importance of solanaceaous crops in the area (tomato, pepper, potato), and the increased importance of exporting tomatoes and peppers to the U.S.

A short list of priority pathogens/pests for East Africa was developed during the Year 3 Regional Diagnostics Training Workshop held in Uganda in July 2008 (see Objective 3). The six selected for initial emphasis were: Banana xanthomonas wilt, banana bunchy top disease, banana fusarium wilt (Panama disease), banana sigatoka, bean root rot, and fruit flies. SOPs are being developed for these priority problems.

This activity has not been completed for the West Africa site due to the postponement of the Regional Diagnostics Training Workshop, but will be a priority for Year 4. A survey of *R. solanacearum* in tomatoes in Benin was completed and a disease note was submitted to the international journal, *Plant Disease*.

**Development of new standard operating protocols (SOPs) for the diagnosis/identification of diseases/pathogens, especially those of quarantine importance**

In Central America, a standard operating protocol (SOP) for ***Ralstonia solanacearum*** is being developed. It will be adapted to meet the needs and diagnostic capacity of laboratories in Central America from the SOP used by the National Plant Diagnostic Network in the U.S. and the protocol developed for East Africa (see below). Pathologists from El Salvador, Guatemala, and Honduras are working together to develop this SOP.

In July 2008, a diagnostics training workshop held in Uganda and four diseases and one insect pest were selected for development of SOPs. One additional SOP was added later on. These protocols are being developed in cooperation with EAPIC.

The level of utility of SOPs and the communications sparked by the development of such documents indicates their importance to diagnostic laboratories and networks globally. The development of SOPs has been a topic included in all IPDN training sessions. Other SOPs in production, based on the NPDN model, are:

- Coffee berry disease (*Colletotrichum coffeanum/kahawae*)
- Citrus canker and other citrus diseases
- Bacterial wilt of beans (*Curtobacterium flaccumfaciens* pv. *Flaccumfaciens*)
- Golden nematode (*Globodera rostochiensis*)

| Crop | Problem & pest | Status |
|---|---|---|
| Banana | **Banana Xanthomonas Wilt** (*Xanthomonas campestris* pv. *Musacearum*) | Draft SOP is about 60% complete in material and about 40% in refinement. |
| Banana | **Banana Bunchy Top disease** (*Banana Bunchy top virus*) | Draft SOP is 60% complete in material and about 50% in editorial refinement. |
| Banana | **Banana Fusarium Wilt** (*Fusarium oxysporum* f. sp. C*ubense*) | Draft SOP is about 75% complete in material and about 60% in editorial refinement. |
| Bean | **Bean root rot** (*Pythium* spp.) | Partial draft that is less than 20% done is available. |
| Wide Range | **Fruit Fly** (*Ceratitis capitata* [Diptera: Tephritidae]) | Draft SOP is about 70% complete in material and about 40% in editorial refinement. |
| Banana | **Sigatoka** (*Mycosphaerella* spp) | Just received an indication of interest from a scientist who wants to make a draft |

**Analysis of diagnostic capacity in each region**

Diagnostic laboratory capacity surveys have been completed in all three regions, with additional surveys done in Ghana in April 2008, in two Ohio workshops in 2007 and 2008, and in East Africa in 2008. Results are currently being compiled, and will be used as part of an invited chapter on Diagnostic Networks being written for the *Annual Review of Phytopathology* (Miller, Beed, and Harmon, authors).

**Development and testing the distance diagnostic and identification system/clinic information management system (DDIS/CIMS) for IPDN**

The beta version of the IPDN DDIS/CIMS (http://www.intpdnddis.org/ipdn/home.jsp) was released during Year 3 and tested in all three regions. Comments on the web portal have been provided to the developer at the University of Florida and the release of the 1.0 version is expected in December 2008. The web portal promotes the rapid diagnosis of any plant problem (disease, insects, weeds, nutritional problems, abiotic problems, etc.) and communication of the results (diagnosis) with clientele. It provides a database for organization of sample information, diagnoses, and recommendations.

For our colleagues in Africa and Central America, the CIMS promotes consistency in the gathering and reporting of information for diagnostic samples received – all users will now provide the same type of information in the same format, allowing comparisons between laboratories and locations. The database will contribute to the gathering of information on pathogen and pest occurrence throughout these regions, which can be used in pest risk assessments and other survey instruments. The DDIS function of the web portal allows diagnosticians to communicate with each other worldwide using digital imaging, and also for the diagnosis of physical samples. The DDIS/CIMS has been received enthusiastically in all three regions in which the IPDN is operating. Subjects such as annual fees and access to confidential data are concerns from local governments and private labs that need to be resolved.

**Regional plant disease diagnostics training workshops**

**East Africa regional training:**

Twenty-six plant pathologists and entomologists (20 men, six women) attended the five-day workshop on diagnosing plant diseases and insect pests of importance to Africa. Participants represented universities and government institutes or programs in Kenya, Uganda, Tanzania, Rwanda, Zambia, and Cameroon. The workshop was held at Makerere University's Department of Crop Sciences in Kampala, Uganda from June 29-July 4, 2008. This workshop was sponsored by the IPM CRSP IPDN (Regional Diagnostic Networks), the IPM CRSP East Africa program, IITA, and USDA Foreign Agriculture Service. The program was organized in cooperation with EAPIC (East African Phytosanitary Information Committee). Funding for most (20 of 26) of the trainees was provided by USDA FAS, which supports EAPIC. The workshop sessions were presented in each of the following thematic areas, by facilitators from Makerere University, USDA-FAS/USAID, Kenya Agricultural Research Institute National Agricultural Research Laboratory (KARI-NARL), the Ministry of Agriculture of Uganda, and The Ohio State University: institutions, phytosanitary trade regulations, and the IPDN; monitoring, detection, and diagnosis in plant diagnostics; application of techniques in plant diagnostics; and communication tools and standard operating procedures in plant diagnostics.

A day-long practical on pest and disease diagnosis was also conducted, emphasizing general principles for laboratory identification of viruses, fungi, bacteria, nematodes, and arthropod pests. A hands-on half-day session was devoted to the use of the DDIS/CIMS (Distance Diagnosis and Identification System/Clinic Information Management System). This was done in the Makerere University computer lab, which has very good internet connectivity and sufficient bandwidth to utilize the web portal. Numerous suggestions were made during the session for improvements to the portal, which were sent to Dr. Xin at the University of Florida, who is the developer of the DDIS/CIMS.

During the workshop, time was devoted to training participants in the development of standard operating procedures (SOPs) for selected pathogens and pests. Working groups were formed with the intention of developing draft SOPs after the workshop. Electronic versions of all presentations and working materials were compiled onto a CD and copies were provided to all participants and resource persons.

Some of the key conclusions of the workshop were that 1) additional in-depth training on diagnosis of high impact pests and diseases is needed; 2) equipment upgrades are needed in most laboratories, although it is recognized that not all laboratories need the same equipment; 3) better access to biotechnology materials and supplies are needed; 4) pest lists are not up-to-date in East Africa and surveillance programs should be instituted; 5) local capacity for diagnostics and pathogen and pest detection and surveillance must be developed; 6) means of reaching farmers with diagnoses ("Test, Don't Guess") and management recommendations need to be improved; 7) communication and cooperation amongst pathologists and entomologists in the African Union (AU) must be improved; 8) library/reference materials on diagnostics are sorely needed in almost all institutions; 9) SOPs should be prepared for diagnosis of the major pathogens and pests, beginning with those of high impact, to standardize approaches in the different countries and institutions; and 10) pest management specialists are enthusiastic about improving diagnostics capacity in East Africa.

**Central America tegional training:**

A five-day training session was attended by 33 diagnostic personnel (seven women, 26 men, exclusive of speakers/organizers) from Honduras, El Salvador, Jamaica, and Guatemala. Instructors from Universidad Del Valle (Guatemala), Universidad Rafael Landivar (Guatemala), FHIA (Honduras), Virginia Tech (U.S.), and the University of Florida offered training in fungal plant pathogens, diagnostic networks, plant nematodes, plant viruses, bacteria such as *Ralstonia solanacearum,* digital diagnostic and communication systems (DDIS,Skype), plant parasitic insects, and development of standard operating protocols (SOPs) for plant diagnostics. Hands-on learning included field sampling and diagnosis, laboratory sections in sample processing for fungi and other plant pests, digital photography for distance diagnostics, and virus diagnostics (ELISA, immunostrip, inclusion bodies, and PCR). On-site learning included a tour and demonstrations at the Mediterranean fruit fly facility (Programma MoscaMed) and a field visit to Escuela Nacional Central de Agricultura (ENCA) vegetable and fruit production fields.

Participants were encouraged to interact with questions and exchange of diagnostic protocols and experiences. Productive discussions occurred regarding sample management, sample form completion, communications, and diagnosis and identification of fungi, bacteria, viruses, insects, and nematodes. Following the SOPs presentation, participants discussed the need for standardization of diagnostics across Central America and the Caribbean. Several participants indicated they would begin developing SOPs for Central American pests and diseases (one specific case included the possible development of a full SOP for all diseases and insect pests of coffee).

Following this introductory session, training is needed in specific identification of Central American diseases, insects, and nematodes. This specialized training, including hands-on identification, would be most productive in small groups, perhaps led by Central American and international experts. Distance education could be helpful for some introductory lessons, but full hands-on microscopic, immunologic, and molecular techniques would be preferable, especially with fresh samples. Funding for such training may need to come from a collective effort in Central America. Joining Caribbean and/or South American efforts may increase the likelihood of funding.

**West Africa regional training:**

The week-long West Africa training program was postponed from September 2008 until January 2009 in order to accommodate participants supported by the USAID West Africa group.

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

A PCR-based assay that specifically detects the bacterium that causes BXW was developed and tested in Uganda and Kenya. The assay was also used to confirm the entry of BXW into Burundi, results of which have been submitted to the journal, *Plant Pathology*, as a first report. The PCR assay was also used to develop management strategies for BXW by determining the distribution of the pathogen in infected banana mats. These results add a new dimension to management recommendations, which now must include destroying all banana stems in an infected mat. It was conducted in collaboration with IITA Uganda and the IPM CRSP East Africa Regional Program.

# Integrated Management of Thrips-borne Tospoviruses in Vegetable Cropping Systems

*Naidu Rayapati, Washington State University*

**Host Countries:** India, Indonesia, Tajikistan, Uganda
**Collaborators:** South Asia Program, Southeast Asia Program, Central Asia Program, East Africa Program, Insect Transmitted Viruses Global Theme.

**Documentation of viruses in vegetables**
This activity was carried out in collaboration with Gopinath Kodetham of the University of Hyderabad; Gandhi Karthikeyan of Tamil Nadu Agricultural University in India; Tri Asmira Damayanti of Bogor Agricultural University in Indonesia; M. K. N. Ochwo-Ssemakula of Makerere University in Uganda; and Zarifa Kadirova of the Academy of Sciences of Uzbekistan.

**Tospoviruses in vegetables**
**South Asia (India):** Reconnaissance studies were conducted for virus diseases in vegetables in several farmers' fields in Uttar Pradesh, Karnataka, Andhra Pradesh, and Tamil Nadu. The results indicated widespread occurrence of peanut bud necrosis tospovirus in tomatoes in several farmers' fields. In addition, observations of tomato fruits in vegetable markets have shown various types of symptoms indicative of tospovirus infection.

The extracts from symptomatic leaves and fruits were spotted on FTA® Classic Cards and shipped to Washington State University for testing by reverse transcription-polymerase chain reaction (RT-PCR) using 'universal' tospovirus primers specific to the large-RNA genome segment of tospoviruses. A DNA fragment of about 860 base pair (bp) amplified from these samples (Figure 1) was cloned into PCR 2.1 TOPO vector (Invitrogen Corp, Carlsbad, CA) and three independent clones were sequenced in both directions. A comparison of sequences from tomato leaves and fruits with corresponding sequences of tospoviruses deposited in the GenBank showed 93-95% nucleotide sequence identity with PBNV from India (GenBank accession no. AF025538). These results confirmed the presence of PBNV in tomato leaves and fruits. Together with field surveys conducted in previous years, these results have established that PBNV is widely distributed across India and has become the major viral disease problem limiting production of tomatoes in India. In addition, PBNV was detected in other crops like cowpea and chile peppers that are grown by small holder farmers, indicating a broader impact of the virus to both vegetable and field crops.

**Southeast Asia (Indonesia):** During field surveys conducted in May 2008 in Warung, Kondang, Cianjur, and West Java, tomato plants in farmers' fields showed stunting with leaves showing either bronzing or general chlorosis with vein-banding, while tomato fruits had concentric rings.. In addition, chilli peppers were observed with chlorosis and vein-banding symptoms in Salabintana, Sukabumi, and West Java. Peanut plants showing tospovirus symptoms (chlorotic rings and necrosis on leaves, petiols, and stem) were observed on the Bogor Agricultural University campus. Since these symptoms in tomatoes, chilli peppers and peanuts are distinct from those caused by other viruses, extracts from symptomatic leaves were spotted onto FTA® Classic Cards and shipped to Washington State University for testing by RT-PCR using 'universal' tospovirus primers for the presence of tospoviruses as described above. A comparison of nucleotide sequences from tomatoes and chilli peppers with corresponding sequences of tospoviruses deposited in the GenBank showed 94-97% nucleotide sequence identity with TSWV isolates from Hawaii (GenBank accession no. AY070218), Wageningen (D10066), Japan (AB198742), and Korea (AB190813). A comparison of nucleotide sequences from peanuts showed 94% sequence identity with corresponding sequence of PBNV from India. These results have established for the first time the occurrence of two distinct tospoviruses (TSWV in tomato and chilli pepper and PBNV in peanut) in Indonesia.

**East Africa (Uganda) and Central Asia (Uzbekisthan):** A survey of four major vegetable markets in the Kampala district of Uganda in Eastern Africa and in the Tashkent area of Uzbekistan in Central Asia was conducted for the presence of tospoviruses in tomato fruits. Several tomato fruits in these markets showed various types of chlorotic rings and blotches indicative of tospovirus infection. A preliminary testing of these fruits using immunostrips from Agdia (Agdia Inc, Elkhart, IN) revealed the presence of Tomato spotted wilt virus and Impatiens necrotic spot virus.

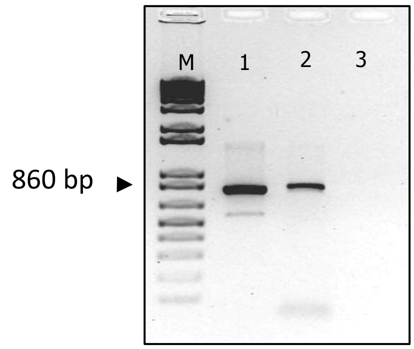



Figure 1 . Agarose gel electrophoresis of RT-PCR products amplified by using tospovirus ‘universal’ primers. Lane 1, PBNV-infected tomato leaf extract spotted onto FTA card; lane 2, positive control and lane 3, negative control. Lane M represents DNA fragments of known molecular weight to estimate the size of DNA band amplified in RT-PCR. The arrowhead on the left indicates the estimated size of DNA fragment from virus-infected samples.

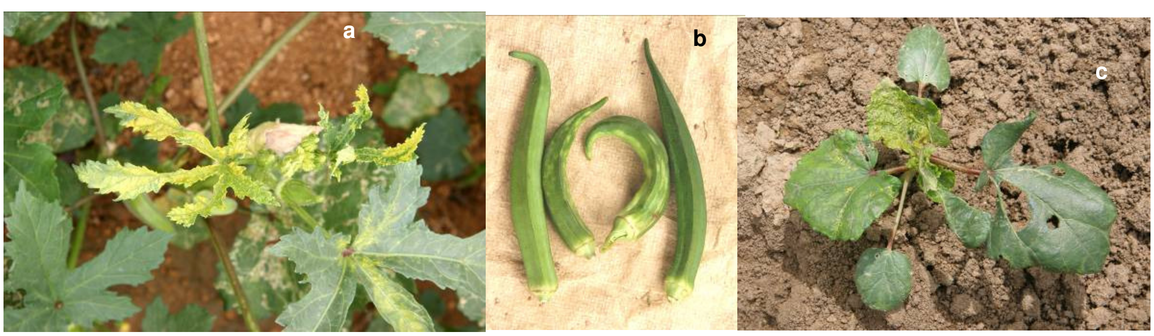



Figure 2. Symptoms in okra caused by tobacco streak virus. An infected plant showing (a) distortion of leaves and chlorotic blotches, (b) fruits from infected plant showing chlorotic streaks and deformations and (c) a young seedling showing symptoms.

## Other viruses

### Tobacco streak virus in okra

Tobacco streak virus (TSV) is an emerging pathogen in a broad range of field crops and vegetables in India. In recent years, TSV has become a major constraint to the cultivation of okra (*Abelmoscus esculentus* (L.) Moench) in India. The infected plants show stunting, distortion of leaves and chlorotic leaf blotches (Figure 2a), and chlorotic streaking and distortion of fruits (Figure 2b). Severe yield losses as much as 60-70 %have been reported by farmers in several states of s`outh India. We have observed young seedlings showing these symptoms indicating possible seed-transmission of the virus in okra (Figure 3c). Further studies are in progress to determine the rate of seed transmission of TSV in okra

### New hosts of *Chili veinal mottle virus* in chilli peppers in India

During our field surveys, *Physalis floridana* and *Solanum nigrum* showing severe mosaic mottling symptoms were observed adjacent to pepper fields and seedling nurseries in India. Extracts from symptomatic plants were spotted on FTA® Classic Cards and brought to Washington State University. The total RNA extracted from these cards was used in RT-PCR for the detection of viruses commonly found occurring in chilli peppers. The RT-PCR results showed amplification of a 700 bp DNA fragment only with primers specific for cytoplasmic inclusion protein of potyviruses. The amplified product was cloned and two independent clones sequenced as described above. A comparison of nucleotide sequences obtained from both species of plants with corresponding sequences of potyviruses deposited in the GenBank showed 96-98% sequence identity at the amino acid level with chilli veinal mottle virus (Chi VMV) isolate from India (GenBank accession no. AJ237843). ChiVMV is one of the most predominant viruses of chilli peppers in India and other Asian countries, and in Tanzania. The information adds to the existing knowledge on reservoir hosts of ChiVMV and underscores the need to consider *P. fliridana* and *S. nigrum* as potential reservoirs of the virus. This knowledge is valuable in developing IPM strategies for the management of ChiVMV in chilli peppers in India and other countries.

### Cucumber mosaic virus in tomato and soybeans in Indonesia

The extracts from FTA cards spotted with tomato and chilli pepper samples from Indonesia were also tested for CMV. The RT-PCR results showed amplification of a 380 bp DNA fragment of virus coat protein (CP) from these samples. Nucleotide sequencing of cloned DNA fragment indicated 99% sequence identity with CMV sub-group I isolates from Japan (GenBank accession no. AB261174), and isolate CK31 (AF5233447) and CK54 (AF523351) from California. In addition, soybean samples showing soybean stunt disease symptoms tested positive for CMV in RT-PCR using CP-specific primers. Nucleotide sequence analysis of cloned DNA fragment showed 91% identity with CMV subgroup I isolates from India (EF153734), U.S. (AF523340), Italy (Y10886), and Spain (AJ829778). These results confirmed the presence of CMV belonging to sub-group I in soybeans showing stunt disease symptoms.

## Identification of thrips species infesting vegetables

Anitha Chitturi, Stan Diffie, and David Riley, University of Georgia

A second-year thrips survey for spring 2008 (January–March) was concentrated at two vegetable growing locations: Maharashtra (onions) and Andhra Pradesh (chili pepper, onions, and tomatoes). A thrips survey was conducted in a total of 22 villages covering three major vegetable crops: onions (varieties: Gauran, Pune Pursangi, Yerragundra), chili peppers (varieties: Teja, Jwala, 002,) and tomatoes (varieties: Vaishali, Ruchi, Suparna, Swathi).

Thrips specimens collected in India were brought to the Coastal Plain Experiment Station at the University of Georgeia, Tifton campus for morphological identification using the key developed by Laurence Mound, CSIRO of Entomology at Canberra, Australia. The thrips species identified are listed in Table 1. We are developing fact sheets on individual thrips species for the benefit of scientists in south Asian countries.

Table 1. Thrips species confirmed by taxonomic identification

| S.No | States | Crops covered | Confirmed species till date |
|---|---|---|---|
| 1. | Maharashtra | Chili peppers, Onions & Tomatoes | *Frankliniella schultzei, Scirtothrips dorsalis, Thrips palmi & Thrips hawaiiensis* |
| 2. | Karnataka | Tomatoes | *Frankliniella schultzei &Thrips palmi* |
| 3. | Andhra Pradesh | Chili peppers<br>Tomatoes<br>Onions | *Scirtothrips dorsalis*<br>*Thrips tabaci* |

**Diagnostic methods for the detection of tospoviruses in plants and thrips vectors**

Gandhi Karthikeyan, and Tri Asmira Damayanti.

Accurate diagnoses of viruses is the first critical step in developing IPM strategies for the management of virus diseases. Among different techniques, molecular diagnostic methods based on Polymerase chain reaction (PCR) technology are used to achieve acceptable levels of sensitivity and specificity in the diagnosis of viruses. However, PCR-based diagnosis involves extraction of nucleic acid from plant samples using specialized reagents and bio-hazardous organic solvents that demand lab safety and personnel protection. In addition, reverse transcription (RT)-PCR is frequently used for sensitive and specific detection of RNA viruses in plants. This is achieved by a two-step process. In the first step, the RT reaction is performed separately under optimum conditions in the presence of reverse-transcriptase to prepare cDNA. A small aliquot is then mixed with a standard PCR reaction mixture for exponential amplification of the viral target. One of the major limitations of this two-step process is increased risk of contamination leading to false-positive results.

An alternative approach was used to limit these potential problems by adapting a simplified and rapid sample preparation method without using any organic solvents and combining both RT and PCR, thereby allowing the simultaneous activities of both the reverse transcriptase and Taq DNA polymerase in the same tube. This protocol was applied for the detection of tospoviruses, cucumber mosaic virus, tobacco streak virus, and potyviruses infecting different plant species including vegetables. The results presented below indicate that the one tube-single step RT-PCR assay offers several advantages including the benefit of decreasing the risk of cross contamination while providing the convenience of reliable and rapid detection of viruses in a cost-effective manner. Thus, this technique is relatively cheaper than conventional RT-PCR methods and, therefore, can be routinely used in developing countries.

**Detection of tospoviruses**

A single tube-one step RT-PCR assay was developed using tospovirus ‘universal’ primers for the detection of different tospoviruses as shown below. In conjunction with molecular biological techniques and bioinformatics tools, we were able to use this technique for the identification of several tospoviruses (Fig. 3) in tomato and chilli peppers in India and Indonesia, and ornamentals in the U.S.

The simplified sample extraction method was also used successfully for one tube-single step RT-PCR detection of TSWV in tomato fruits collected from retail markets. This technique can be used for the detection of TSWV in Indonesia and extended to detect other tospoviruses like PBNV in tomato fruits in India.

**Detection of Tobacco streak virus (TSV)**

TSV has become a major disease in okra and other vegetable and field crops in India. Since symptoms produced by TSV infection overlap with diseases caused by tospoviruses (PBNV) and geminiviruses (Bhendi vein mosaic virus), a sensitive method for accurate diagnosis of TSV in symptomatic okra plants, fruits, and seeds is essential for disease management. The simplified sample extraction method was used successfully for the development of one tube-single step RT-PCR assay for the detection of TSV in leaf samples. This technique will be of great value for the detection of TSV in India and other countries.

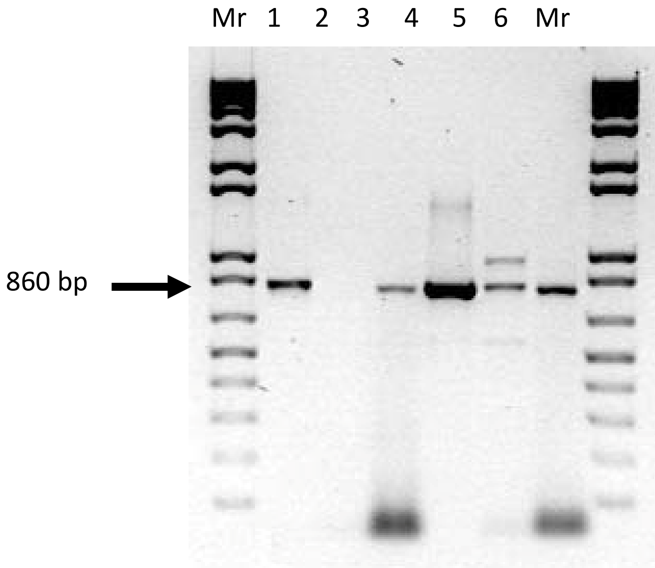



Figure.3. One tube-single step RT-PCR detection of several tospoviruses using tospovirus 'universal' primers. The virus-specific DNA band was amplified from infected material (lane 1 = Tomato spotted wilt virus (TSWV) from the U.S. as a positive control, lane 2 = healthy control, lane 3 = TSWV from Indonesia, lane 4 = Impatiens necrotic spot virus from US, lane 5 = Iris yellow spot virus from US, lane 6 = Peanut bud necrosis virus from India. The 860 bp DNA band (in black) amplified from infected samples (indicative of the presence of tospovirus), is indicated by an arrow on the left. Mr = DNA bands with known molecular weights run in the same gel for estimating the size of virus-specific DNA bands.

**Detection of Cucumber mosaic virus (CMV)**
CMV infects a broad range of vegetable crops and exists as two serologically distinct sub-groups. We have developed a simplified sample extraction method in conjunction with one tube-single step RT-PCR assay for the discrimination of the two subgroups of CMV. The DNA fragments of two distinct sizes (860 bp DNA band specific to CMV subgroup II and 422 bp DNA band specific to subgroup I) allows easy discrimination of the two subgroups. This technique has been used successfully for the detection of CMV subgroup I in tomato and soybeans in Indonesia.

**Detection of potyviruses**
Several distinct potyviruses transmitted by aphids infect a broad range of vegetables. An RT-PCR assay that can detect these viruses would be a valuable tool in developing IPM strategies against potyviruses in vegetables. Towards this objective, we have developed a simplified sample extraction method in conjunction with one tube-single step RT-PCR assay for the detection of different potyviruses infecting vegetables (Tobacco etch virus, Lettuce mosaic virus, Bean yellow mosaic virus).

In conjunction with RT-PCR assay for the detection of the two subgroups of CMV, this assay can be used for the detection of mixed infections of CMV and potyviruses. The DNA fragments of two distinct sizes (422 bp DNA band specific to CMV subgroup I and 1 kbp DNA band specific to potyvirus) allows easy discrimination of the two viruses.

Since CMV and potyviruses are transmitted by aphid vectors, the RT-PCR technique we have developed is convenient for simultaneous detection of two taxonomically disparate viruses in diseased plants, and permits sorting of samples for single and mixed virus infections.

**FTA® Classic Card technology for the detection of viruses**
In recent years, the practical application of FTA® Classic Card technology has been demonstrated for sampling, retrieval and PCR-based detection of DNA viruses infecting plants. We have begun extending this technology for the diagnosis of RNA viruses like tospoviruses and cucumber mosaic virus infecting vegetables.

**Tospoviruses**

Tomato samples (leaf and fruit from farmers' fields and vegetable markets) from India and tomato, pepper, and soybean samples from Indonesia suspected of virus infections were pressed on FTA classic cards and shipped to Washington State University (with appropriate permit fro USDA-APHIS-PPQ) for the detection of tospoviruses by one tube-single step RT-PCR using tospovirus 'universal' primers as described in activity 2.1. Instead of multi-step processing of FTA cards using several chemicals including FTA® Purification Reagent as recommended by the manufacturers, we have modified the simplified and rapid sample preparation method described in activity 2.1 for recovering viral nucleic acid from diseased plant samples pressed on FTA cards that had been stored at room temperature. We were able to amplify tospovirus-specific DNA fragments by RT-PCR from extracts recovered from FTA cards. To ascertain that the RT-PCR amplified DNA fragment in each sample was indeed specific to tospovirus, we cloned the DNA fragments and determined the nucleotide sequence. A comparison of nucleotide sequence with corresponding tospovirus sequences in the GenBank revealed that tomato samples from India contained PBNV, and tomato and pepper samples from Indonesia contained TSWV. In addition, the FTA Classic Card technology was successfully used for the detection of cucumber mosaic virus in tomato and soybean samples.

These results indicate that FTA® Classic Cards can be used for sample collection in the farmers' fields, and simplify sample transportation to a central location for virus testing and downstream applications like molecular analyses of viral genomes. Further studies are required to make this technology accessible for a wide range of applications in virus diagnosis in developing countries.

**Linkages with other global and regional IPM-CRSP projects**

Rayapati has established project linkages with the regional project, "Ecologically-based participatory IPM for Southeast Asia," (PI Michael Hammig) to explore collaborative activities on tospoviruses in vegetables in the region. As part of strengthening these collaborations, Dr. Rayapati provided practical training in characterization and diagnosis of different viruses infecting vegetables to Dr. (Mrs.) Tri Asmira Damayanti, a virologist at Bogor Agricultural University, Darmaga Campus, in Bogor, Indonesia.

Rayapati established linkages with the global theme project, "Collaborative Assessment and Management of Insect-transmitted Viruses," (PI: Sue Tolin) and exchanged information on virus diseases and methodologies for the detection of viruses. Both PIs are organizing a scientific session, "IPM strategies for the management of insect transmitted plant virus diseases," at the 6th International Symposium in Portland, OR, during March 24-26, 2008.

Rayapati established linkages with public research institutions (National Center for Plant Biotechnology, National Center for IPM, Central Research Institute for Dryland Agriculture, University of Hyderabad), private sector seed companies, and NGOs in India to advance IPM CRSP program activities in India. Rayapati also established linkages with the Growth and Micro Enterprise Development (GMED) project in India funded by USAID for collaborative activities in the areas of IPM and management of vegetable virus diseases to produce quality vegetables by smallholder farmers.

# Collaborative Assessment and Management of Insect Transmitted Viruses

*Sue Tolin, Virginia Tech*

**Co-Investigators:**
Judy Brown, University of Arizona
Carl Michael Deom, University of Georgia
Bob Gilbertson, University of California at Davis
AVRDC – The World Vegetable Center
International Institute of Tropical Agriculture
**Host Countries:** Burkina Faso, Cameroon, Mali, Guatemala, Honduras, Dominican Republic, Jamaica
**Collaborators:** International Plant Diagnostic Laboratories Global Theme, Impact Assessment Global Theme, Thrips-Transmitted Viruses Global Theme, Information Technology and Databases Global Theme, West Africa Regional IPM Center

**Inventory of viruses of vegetable crops in host countries.** Comprehensive information on viruses of solanaceous (tomato, pepper, eggplant, etc.) and cucurbit vegetable crops has been compiled at Virginia Tech by a graduate student from Jamaica using published literature and o-line resources in plant virology. Currently, the data set resides in an Excel spreadsheet and consists of information on name, taxonomy, and properties of each virus, along with diagnostic methods, host range, symptoms, insect vector, and other transmission characteristics, including seed and mechanical and geographic distribution, with links to other sites. Data can be sorted to show all viruses on a host, such as tomato (Figure 1). Other data fields include information about each virus such as genome type, size, and sequence(s) in Genbank by accession number, coat protein size(s), and serological diagnostic test availability for each virus. A second data set is being populated with viruses that have been identified over time in each of the host countries. As viruses are detected for the first time, or new viruses characterized, additions to the database are being made. This number is increasing as diagnostic capabilities improve in each of the host countries, as well as those in collaborating global theme and regional projects, and more viruses are diagnosed. For example, *Tomato yellow leaf curl, Mali virus*, *Tomato leaf curl Mali virus*, *Pepper yellow vein Mali virus*, *African cassava mosaic virus*, the potyviruses *Pepper veinal mottle virus*, *Papaya ringspot virus*, and *Cowpea aphid borne mosaic virus*, and *Potato virus X* have been recently identified in Burkina Faso. Guatemala, Honduras, and Jamaica have lists of plant viruses that have been detected, many of of which include location, date, and specific crop. Discussions are underway with the Global Theme on information technology and databases on mechanisms to access both types of information and make them accessible to IPM CRSP collaborators. This will help in the assessment and improvement of diagnostic capabilities in host countries.

Diagnosis of plant viruses increasingly relies upon the use of serological or molecular methods that require trained persons and costly reagents as well as clean, well-equipped laboratories. U.S. cooperators, AVRDC, and IITA, have focused on building capacity both in facilities and in training, and in testing samples taken from host countries. Collaborating laboratories in Central America and the Caribbean have varying degrees of expertise and facilities to conduct virus diagnosis. Anecdotal comments from many are that the major constraint to virus diagnosis is the timely and affordable acquisition of materials because of import restrictions. To substantiate the constraints and to better understand in-country capabilities and needs, a survey instrument has been prepared in the Tolin lab to be distributed to participants of workshops sponsored by the IPDN Global Theme. It has been translated into Spanish for scientists who have attended diagnostic workshops.

In Guatemala, the Univ. del Valle de Guatemala (UVG) group, led by M. Palmeiri, performs PCR-based detection of geminiviruses in host plants and whitefly vectors, which has facilitated monitoring studies to design a management strategy for viruses in the Salamá Valley.

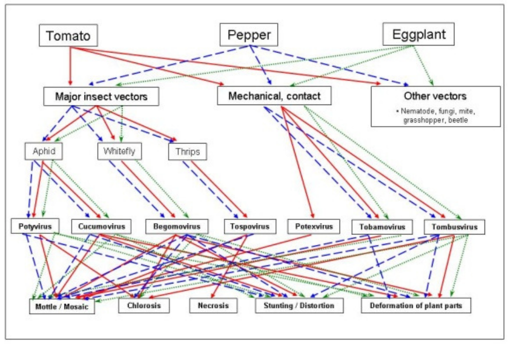



Figure 1. Viruses on tomato, pepper and eggplant sorted by vector, virus genus, and symptom.

Training modules have been developed for students and professionals in RNA and DNA extraction, and in PCR and RT-PCR with degenerate and specific primers. The UVG group has also trained M.S. students from Rafael Landivar University in ELISA and inclusion bodies for light microscopy. Three students were trained in whitefly classification by microscopic differentiation of adults with an optical microscope and identification of whitefly nymphs. A student working on whitefly biotypes was sent to the J. Brown Laboratory at the University of Arizona to amplify sequences of *B. tabaci* samples to determine the biotypes. While there, he also learned how to use software to analyze those sequences and to do the phylogenetic trees. Palmeiri's group also conducts ELISA for several RNA viruses using kits purchased from Agdia. Following two instructional workshops conducted by Tolin, the lab has begun to utilize nitrocellulose-based tissue blot immunoassays (TBIA), particularly with the potyvirus *Papaya ringspot virus* and with tobamoviruses. The first workshop followed the planning meeting of this project in December, and the second was a part of the July IPDN workshop.

Honduran labs at FHIA have used ELISA kits extensively in previous years. The materials were obtained from U.S.-based suppliers (Agdia, Sigma, etc.) and included kits/reagents for detection of viruses in the genera Cucumovirus, Tobamovirus, Begomovirus, Potyvirus, and Tospovirus. FHIA ordered ELISA kits in April 2008 for in-country analyses of several viruses. Unfortunately, local delays in the ordering process resulted in receipt in September, which precluded performing any local analyses this year. The kits will still be used for analyzing stored samples, and on samples collected during the coming vegetable growing season that runs from October through June. Zamorano University labs also have conducted PCR and ELISA, and have established collaborations with the Central Scientific Laboratory in the United Kingdom as well, taking advantage of their electron microscopy facilities to try to detect virus particles in leaves with virus-like symptoms that are negative to other tests. Personnel from Zamorano attended the workshops in Guatemala demonstrating TBIA, and plan to incorporate this method into their repertoire of diagnostic methods. Additional TBIA training in Honduras is planned to facilitate use of this method in addition to ELISA kits.

A new diagnostic laboratory in the Dominican Republic for T. Martinez has been constructed and equipped with the assistance of the Deom Lab at University of Georgia. Equipment added this year includes a -20°C freezer, a water bath, electrophoresis power supply and chambers, ultraviolet light for viewing gels, and a microcentrifuge, which are items needed for PCR and ELISA. The aphid-transmitted *tobacco etch potyvirus* (TEV) and *cucumber mosaic virus* (CMV) were identified by ELISA, and immunostrips were used for quick CMV detection. In Jamaica, the University of the West Indies' labs have full PCR as well as nucleotide sequencing capability, and are completing work on molecular diversity of TEV. Sequence comparison suggests that some of the isolates serologically positive for

TEV may actually be a different virus. At the Ministry of Agriculture and Lands, a tissue blot immunoassay for geminivirus permitted temporal sampling of tomatoes in Jamaica. Training is still planned for a Dominican Republic scientist to improve her diagnostic skills for begomoviruses by visiting the University of the West Indies, and by being trained in TBIA.

In west African countries, the diagnostic capability appears to be less developed. Scientists collaborating with this project from Burkina Faso and Cameroon are both currently in degree programs at European universities, and have the intent to build in-country diagnostic capabilities. Many diagnoses have been done in labs off of the continent. Burkina Faso and Cameroon have been encouraged to collaborate with Mali and with governments associated with the IPDN hub lab in Mali, perhaps as spoke labs. Discussions are ongoing with the IPDN Global Theme and the West Africa site.

**Application of diagnostics to viruses and vectors in African vegetable systems**

**a. Appraisal of predominant, problematic viral diseases and whitefly vectors in Burkina Faso cropping systems.** More than 500 samples from tomato and peppers were collected throughout the country by M. Koutou. From preliminary tests, the incidence of begomovirus was estimated in the three main agro-ecological regions of Burkina Faso. The Sudan savannah zone (central part of the country) had the highest incidence with 27% of positive samples, followed by North Guinean savannah (southern part of the country) with 21%, and then the Sahel with 12%. Additional analysis indicated that *pepper yellow vein Mali virus* is a more predominant species than tomato yellow leaf curl species. Characterization of these two begomovirus species was possible by using degenerate primers. Molecular data and serological detection using monoclonal antibodies from the Scottish Research Institute (SCR) showed three main begomovirus groups, suggesting that there are at least three virus species infecting solanaceous crops in Burkina Faso. There is a need to sequence more samples in order to find out the genetic diversity of begomovirus infecting tomato and pepper in Burkina Faso. Samplings from tomato in two of the three ecological regions indicated that *Bemisia tabaci* is a predominant whitefly species. DNA sequencing of the PCR product (850 bases) suggests Burkina Faso whiteflies are members of the large north Africa/Middle East/Mediterranean clade, which are typically polyphagous populations. This suggests that the whitefly vector is likely to spread begomoviruses among different crops and weed hosts. Another collection which will include the Sahel samples is being made to confirm these preliminary results.

**b. Appraisal of begomoviruses and whitefly vectors in Cameroon.** Two isolates of *Okra yellow crinkle virus* (OYCrV) and two isolates of *Cotton leaf curl Gezira virus* (CLCuGV), one being a recombinant of CLCuGV and OYCrV, together with their associated DNA beta satellites, have been completely sequenced as a part of work by W. Leke for his Ph.D. in Sweden. FTA card technology was implemented for the collection, storage, and recovery of begomovirus DNA. One isolate is a putatively new virus from tomato that is nearly identical to *tomato leaf curl Ghana virus* at 87% and most likely a recombinant. OYCrV has also been identified in *Asystasia* spp. and thus represents a potential host for OYCrV in Cameroon. Two isolates of new kinds of DNA-1 have been cloned and completely sequenced from okra. Two isolates of a putatively new DNA beta satellite were cloned and completely sequenced from *Ageratum*. This weed and others are being examined for their role in theepidemiology of the virus.

**c. Etiology of okra leaf curl disease in Mali.** The University of California-Davis group has continued characterization of begomoviruses associated with okra leaf curl disease (OLCD) in Mali. They have established that OLCD is caused by a complex of begomoviruses (*Okra yellow crinkle virus*-[Mali: 2006] and *Cotton leaf curl Gezira virus*-Mali [Mali: Okra: 2006]: CLCuGV-ML [ML:Ok:06]) and a promiscuous betasatellite (*Cotton leaf curl Gezira betasatellite*-[Mali:Okra:2006]). These begomoviruses are very different from the tomato-infecting begomoviruses from West Africa, as described in a paper in *Archives of Virology* by Zhou et al. in 2008. CLCuGV-ML[ML:Ok:06] was also shown to be a recombinant virus, composed of sequences of CLCuGV (major parent) and a *hollyhock leaf crumple virus* (HoLCrV)-like virus (minor parent). Infectivity studies were also performed in cotton to address the question of whether either of these begomoviruses, with or without the betasatellite CLCuGB, could induce disease symptoms in this economically important crop in West Africa. Fortunately, our results indicated that these viruses do not infect cotton, whether alone or when coinoculated with CLCuGB. In control experiments, cotton seedlings were infected with cloned DNAs of *cotton leaf crumple virus* from southern California, which indicated that our inoculation protocol worked. It will be important to continue to monitor cotton in West Africa for the emergence of a cotton-infecting CLCuGV variant.

**d. First report of *Cucurbit yellow stunting disorder virus* in Mali.** In previous trips to Baguineda, in the irrigated rice-vegetable production area where the University of California-Davis group and the West Africa Regional IPM Center have been implementing IPM strategies for management of whitefly-transmitted tomato-infecting begomoviruses, interveinal yellowing symptoms that are typical of whitefly-transmitted criniviruses have been observed. Using a membrane-based RT-PCR detection method, we amplified DNA fragments of the expected size with degenerate primers for criniviruses. Sequence analysis of these fragments revealed >95% identity with sequences of *cucurbit yellow stunting disorder virus* (CYSDV). This represents the first report of CYSDV in Mali. As CYSDV can cause serious losses to cucurbit production, it will be important to alert growers and extension agents to this new disease and to consider means of disease management.

**e. Whiteflies in West Africa.** Work has been initiated in Cameroon and Tanzania/Uganda on molecular analysis of the whitefly *(Bemisia tabaci)* vector of begomoviruses, to conduct haplotyping of collections from various crops and weeds. Initial analyses will be performed in the Brown Lab at University of Arizona, but primers (mtCOI) will be made available for optimization in all three African labs and amplicons will be sent for DNA sequencing as a pilot test. Linkage has been made with the West Africa Regional IPM Center to assist them in categorizing whitefly collections in Senegal and Mali.

**Application of diagnostics to viruses and vectors in Central America and the Caribbean vegetable systems**

**a. First report of *Tomato yellow leaf curl virus* in Guatemala.** In surveys of tomato production in the Salamá Valley and other locations, disease symptoms that look similar to those induced by TYLCV have begun to be observed (Figure 2). Scientists from the University of California-Davis and the Univ. del Valle have established that these symptoms are caused by an isolate of TYLCV based on 1) positive signals in squash blot hybridization tests with a TYLCV-specific probe, 2) squash blot-PCR amplification of expected sized fragment with TYLCV-specific primers and 3) sequence analysis of these fragments indicating >95% identity with TYLCV isolates from Israel, Mexico, and the Dominican Republic. This finding adds another begomovirus to the already complex mixture of these viruses in Guatemala and will likely complicate efforts to manage this damaging complex of viruses.

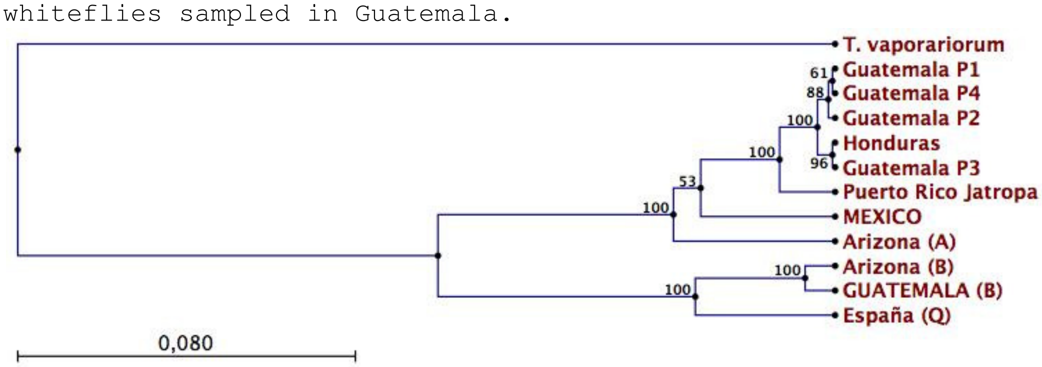
**b. Characterization of an RNA virus associated with the chocolate spot disease of tomato in Guatemala.** The University of California-Davis group has basically completed the molecular characterization of the virus causing chocolate spot disease in Guatemala. It has been established that this virus has spherical particles ~25-28nm diameter and that it is sap- and graft-transmissible to tomatoes and other solanaceous hosts. The viral genome is composed of two RNA species of about foru and eight kilobases each. Sequence analysis of these RNAs have revealed a genome organization similar to those recently described for *tomato apex necrosis virus* (ToANV), *tomato torrado virus* andt*Tomato marchitez virus*; these are new picorna-like viruses that induce necrosis symptoms in tomato. However, the sequence of the Guatemala virus is distinct (<80% identical) from these previously characterized viruses, indicating it is a new virus. Thus, the name tomato chocolate spot virus is proposed. A rapid PCR method for detecting this virus has been developed and it is being tested in Guatemala. We have also determined that the chocolate spot virus can be detected with an immunostrip developed for ToANV. These tests should be useful tools for understanding the ecology and biology of this new virus and for developing management strategies.

**c. Application of diagnostics to whitefly vector analysis in Guatemala.** Guatemala has conducted extensive sampling for the presence of specific whitefly genotypes/biotypes, and is using this information to recommend host-free strategies to manage diseases caused by begomoviruses. Samples were collected in different regions of the country.

Figure 2. Typical symptoms of TYLCV in tomato in the Salamá Valley of Guatemala

In the western region, samples were from Zacapa, Santa Rosa, Jutiapa, Jalapa, Chiquimula, and El Progreso, in the central region from Guatemala and Baja Verapaz, in the northern region from Petén, and in the southern region from Retalhuleu and southern Quezaltenango. For all of the samples, data were taken on altitude, GPS coordinates, name of the plantation, and family. The samples were selected in an specific pattern, varying with altitude and crop, including cucurbits, solanaceae, malvaceae, maleza, and others, from 2006 to 2008. There were at least five samples in each category. Whiteflies were collected and classified to species. For each sample the sex was determined and then DNA was extracted using Frolich *et al.* (1999) protocol. The samples were then subjected to PCR using primers for Cytochrome Oxidase I (COI) gene specific for *B. tabaci*. All PCR samples were classified with single strand conformational polymorphisms (SSCP) that gave different patterns, and were used to select 73 of the 300 for sequencing with the help of the Brown Lab at the University of Arizona. Preliminary analysis of sequences suggests first, that only local races of whiteflies are present, and that B and Q biotypes (from the old world) may not be present in the localities sampled, and second, that the analyzed population of *B. tabaci* from Guatemala is sub-divided in four different local races, named 1P, 2P, 3P, and 4P (Figure 3), differing only in seven base pairs. The Guatemalan B biotype clusters with the Arizona B biotype. Mapping the location of the races showed a relationship to the altitude of the collection (Figure 4).

Figure 3. Phylogenetic analysis of cytochrome oxidase gene (COI) of whiteflies sampled in Guatemala.



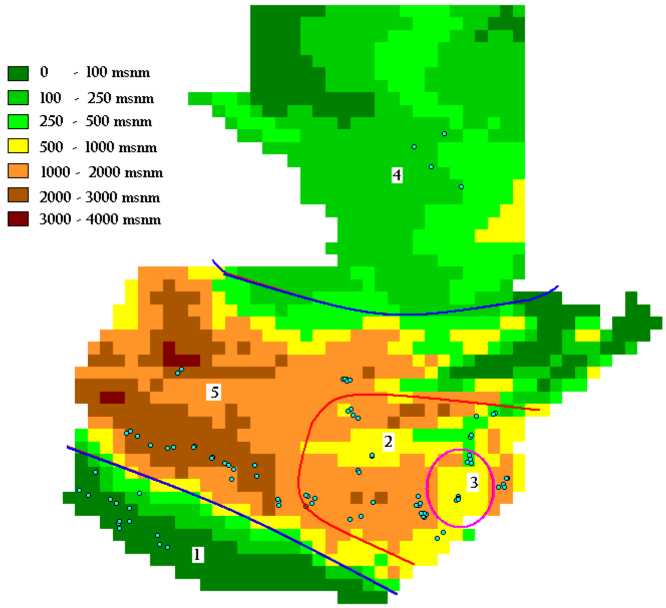



Figure 4. Location of sampling points in relation to altitude, using the program Diva-GIS. Numbers refer to races of population of *Bemisia tabaci* (P1-P4) and *Trialeurodes vaporariorum* (P5).

**d. Detection of viruses in Honduras.** In November 2007, Wen-shi Tsai (AVRDC, Taiwan) visited the important horticultural area of the Comayagua Valley in Honduras. A total of 39 samples (14 peppers, 15 tomatoes, 2 *Sida acuta*, 5 bitter gourds, 2 cucumbers, and 1 papaya) were collected and later sent to AVRDC where they were analyzed. Using begomovirus general primers and PCR, positive results were obtained for 12 of 14 pepper samples, all 15 tomato samples, and one papaya sample. An aphid-transmitted potyvirus was detected by ELISA in four pepper and two tomato samples. Samples were also collected from a pepper trial in Zamorano, where begomovirus was detected in only three of 897 samples. This virus is being sequenced at AVRDC to establish its exact identity. Broad bean wilt virus (BBWV) was detected by AVRDC in two of the symptomatic pepper plants by ELISA using antiserum from DSMZ, Germany. This finding needs additional confirmation, as BBWV does not normally infect pepper. The yellowing symptoms of the other PCR negative plants may have been caused by nutrient deficiency or by other viruses for which no tests were conducted.

The M. M. Roca Laboratory at Zamorano has forged strong relationships with private companies specializing in viral diagnostics, mainly Agdia and Envirologix in the U.S. The goal is to move forward in developing quick, efficient, and inexpensive diagnostic technologies. There continue to be a large number of negative-testing samples with virus-like symptoms that will be explored to identify the causal agent(s). The current hypothesis is that the tropical viruses are not sufficiently related to antisera used in commercially available tests to give positive reactions. This could be due to large strain differences, or to the presence of new viruses not included in banks of antiserum prepared largely from viruses isolated in temperate regions. These possibilities are being explored with Project Director Tolin, which also has a relationship with Agdia.

**e. Detection and assessment of viruses in pepper and tomato in Dominican Republic.**

During the year 2007-2008, the IDIAF group led by T. Martinez worked on diagnoses of TEV and CMV on protected crops as well as in open fields. Protected crops (large greenhouses) are producing more peppers and tomatoes, however, this system is more or less new in the Dominican Republic, and there is little experience in regarding viruses in them. Three viral diseases have been identified: tomato spotted wilt virus (TSWV) on pepper and tomato, CMV on tomato, and pepper mild mottle virus (PMMV) on pepper. The latter is a tobamovirus known to be seed-borne and mechanically transmitted. It was identified from samples send by a grower to the U.S.

The identity and distribution of aphid-transmitted viruses on pepper in 11 farms in nine localities in the Ocoa Valley was monitored by Martinez of ELISA using Agdia kits. In four localities, CMV and TEV were detected and caused typical symptoms at a high but variable incidence, with dual infection common. In Nizao, all 7 samples were positive for TEV and four of those were also CMV positive. In Las Auyamas, all 12 were TEV positive, with three of the 12 also having CMV. In one field in Sabana Larga all seven were TEV positive with four also CMV positive. A second field found four of seven were TEV positive and six of seven were CMV positive. In La Ciénega, five of six samples were TEV positive, but no CMV was detected. In the other five localities, 25-35% of the plants showed viral symptoms, but were negative when tested for TEV or CMV.

**f. Detection and diversity of aphid-transmitted viruses in Jamaica**

The University of the West Indies (W. McLaughlin) is well-equipped for molecular detection of viruses, and has acquired an ABI nucleotide sequencer, thus giving them the capability to sequence PCR amplified and/or cloned viral nucleic acids. Recents efforts have focused on TEV from hot peppers, specifically obtaining sequences from a number of isolates from infected Scotch Bonnet pepper. Funding has been obtained to examine more TEV isolates. Sequence analysis will allow the confirmation that TEV in Jamaica is a highly aphid-transmissible strain, which is of significance and could explain the very high incidence levels and rapid spread of TEV in hot peppers throughout the island. Preliminary data suggest the existence of a distinct virus. Plans have been made to analyze isolates from Dominican Republic peppers as well. These data can be used in molecular ecology studies of strain distribution, transmissibility, and severity in peppers. Ministry of Agriculture personnel are assisting in collecting samples that are potentially infected with CMV, and providing tissue blots on membranes to the Tolin Lab for a study on the diversity of CMV by a graduate student with the IPM CRSP.

**Ecology and management of insect transmitted viruses in tomato and pepper in the Caribbean**

**a. Monitoring of *Tomato yellow leaf curl virus* (TYLCV) in whiteflies to assess the continued effectiveness of the 3 month host-free period in the Dominican Republic.** The implementation of a three-month whitefly host-free period in the Dominican Republic (DO) continues to be a key component of a successful IPM program for the management of this damaging virus. As part of the IPM CRSP activities, the University of California-Davis group continued their efforts applying a PCR detection method for TYLCV in whiteflies to assess the efficacy of the host-free period in the two major tomato-growing areas of the DO, the North (around Santiago) and the South (Azua Valley); as well as in Ocoa, an area where there is no host-free period. During the host-free period (June-August 2007), the amount of TYLCV in whiteflies decreased dramatically such that little virus was detected in whiteflies collected at the end of August. These low levels continued into the beginning of the tomato-growing season (September-October). By the end of November, whiteflies had considerably higher levels of TYLCV and this continued through the rest of the growing season (April/May 2008). Once the host-free period was implemented and sanitation efforts resulted in the removal of old infected plants in harvested fields, the amount of TYLCV in the whiteflies dropped again such that whiteflies collected at the end of July and August had no detectable virus.

Thus, the host free period continues to be effective, reducing levels of viral infection early in the season, thereby allowing the planting of TYLCV-susceptible varieties. Moreover, growers seem to recognize the importance of this program and it has become a standard practice in many areas of the Dominican Republic.

**b. Implement a host-free period IPM strategy for viruses in the Salamá Valley of Guatemala.** Based on successful approaches in other locations, the goals are to obtain data to establish a host-free period as an IPM strategy to manage viruses in this location. Work was done by M. Palmeiri and her associates and students at the U. del Valle, and by

R. Gilbertson (UC-Davis) using leveraged funding from farmers' groups and the Government of Guatemala.

The basic aspects that we are covering in this objective are:

- Familiarization of growers and field technicians with the importance of host-free period timing/planting dates for management of begomoviral infections.
- Train growers and field technicians on whitefly collection and sampling.
- Optimize diagnostic methods for detecting begomovirus in whitefly vectors.
- Perform monthly monitoring of begomoviral load carried by whiteflies in the Salamá Valley and in Santa Rosa in greenhouses, if allowed; if not, in field conditions.
- Establish temporal epidemiology of begomovirus in whitefly vectors in the Salamá Valley and in Santa Rosa.

Monthly visits were made to five fields located in the four cardinal points and the center of the Salamá Valley as well as in Santa Rosa. Each field corresponded to a sample collection point where approximately 100 whitefly adults were collected and transported to the laboratory in 80% ethanol where they were classified by gender (male/female) and species (*Bemisia tabaci, Trialeurodes vaporariorum*, among others). The adult identification was based on compound eyes. The determination of sex was based on the last segment of the abdomen. From each sample collection point and time, ten female *B. tabaci* were selected for detection of begomoviral load by PCR. The test is well optimized to detect the viral load of a single whitefly. Generic primers were used initially, but specific primers are now used for pepper huasteco virus, pepper golden mosaic virus, havanna mosaic virus and severe leaf curl yellow virus, all having been reported in Guatemala and other countries in Central America. Two weeks after the sampling, growers get a report including the whitefly distribution by gender and species and the begomoviral load in *B. tabaci*. Virus load was determined in *T. vaporariorum*, initially, but this species was seldom positive. The monthly data of begomoviral load were analyzed calculating the mean of the percentage of virulence of the fields to obtain the begomoviral load of the corresponding month. The values generated for each month established temporal epidemiology of begomovirus in whitefly vectors in the Salamá and Santa Rosa valleys throughout the year. Data in Table 1 (pg. 125) shows the temporal abundance of whiteflies. A total of 372 *B. tabaci* females were tested, of which 34% were positive. The viral load is an indicator of the proportion of virus transmission capable vectors available in the valley which, when comparing to last year's data from the same months, has decreased to half. This result could be due to the constant training of the technicians in the area who have been in charge of checking on the growers for good crop practices. In Santa Rosa, sampled fields had fewer vectors. Out of a total of 120 *B. tabaci* females tested, 27% tested positive for Begomovirus. Such data are needed to recommend host-free periods to farmers.

In November 2007, FASAGUA, which is the institution collaborating with the whitefly monitoring effort, published the annual calendar for planting tomato and pepper in the different areas of the country. They based this calendar on the results obtained by the extended whitefly monitoring that we are performing, because we not only sample Salamá and Santa Rosa's valleys, we have extended sampling to 15 other valleys. Information is available to growers on the FASAGUA website.

The principal impact that this study will have, and has begun to have, is that the growers are able to know when to plant and when they will have viral problems. Also, they are now aware of the factors that affect their crops. They will see that diseases will not be controlled by only applying pesticides, and that they must understand disease cycles and factors that affect them. Also, they will be aware of different crop possibilities, not only the crop that they are accustomed to planting. For example, instead of planting nothing during the two months needed for the elimination of begomovirus in a generation of *B. tabaci*, they can still plant a non begomovirus host.

**c. Monitoring whitefly populations and the spatial and temporal dynamics of TYLCV in tomato fields in Jamaica.** Whitefly populations were monitored in two southern parishes of Jamaica, St. Elizabeth and St. Catherine, where tomatoes are grown. Fields monitored in St. Elizabeth were located in the Top Hill and Southfield districts, and in St. Catherine, fields were monitored in the Bushy Park and Thetford districts.

Table 1. Whitefly species and begomoviral load in samples from the Salamá Valley of Guatemala

| | | PCR tests | | Whitefly Classification | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR | MONTH | Tests on *B. tabaci* | *B. tabaci* (+) | *B. tabaci* females | *B. tabaci* males | *T. vaporariorum* females | *T. vaporariorum* males | Other species | TOTAL |
| 2007 | OCTOBER | 12 | 4 | 11 | 2 | 52 | 28 | 0 | 93 |
| | NOVEMBER | 20 | 2 | 33 | 17 | 31 | 34 | 2 | 117 |
| | DECEMBER | 25 | 20 | 120 | 70 | 151 | 62 | 2 | 405 |
| 2008 | JANUARY | 50 | 5 | 108 | 136 | 76 | 136 | 2 | 458 |
| | FEBRUARY | 40 | 10 | 96 | 284 | 29 | 29 | 0 | 438 |
| | MARCH | 50 | 15 | 188 | 210 | 35 | 15 | 3 | 451 |
| | APRIL | 26 | 17 | 115 | 59 | 36 | 19 | 0 | 229 |
| | MAY | 31 | 11 | 85 | 51 | 43 | 27 | 0 | 206 |
| | JUNE | 29 | 12 | 62 | 55 | 29 | 23 | 0 | 169 |
| | JULY | 13 | 1 | 37 | 57 | 52 | 40 | 0 | 186 |
| | AUGUST | 39 | 28 | 65 | 93 | 15 | 11 | 3 | 187 |
| | SEPTEMBER | 37 | 0 | 91 | 6 | 19 | 6 | 0 | 122 |
| | **TOTAL** | **372** | **125** | **1011** | **1040** | **568** | **430** | **12** | **3061** |

A specific experiment was established at the Ministry of Agriculture Research Station at Bodles, St. Catherine, Jamaica in late July 2007 and continued into October 2007. The study site was approximately 0.09ha and comprised two plots, each with 11 rows of 62 tomato plants (i.e. 682 plants per plot). Virus-free tomato seedlings (var. 'UC 82') were grown within a screen house to exclude whiteflies. Before transplanting, tissue blots were taken from a random sample of 100 seedlings to confirm the absence of TYLCV by serological means. After the seedlings were transplanted, each tomato plant was observed weekly for symptoms of TYLCV infection. The symptoms of TYLCV appeared as yellow leaf margins, leaf cupping, and reduced leaf size. Symptomatic tomato plants were tagged with a different colored flag each week. Tissue blots were taken from 10 randomly selected symptomatic tomato plants for each week's infection. Leaf tissue was also taken from these symptomatic plants to confirm the presence of TYLCV using ELISA. Whitefly flight pattern was monitored during the study using a pair of yellow sticky traps. Traps were removed and replaced each week and the number of whiteflies on each counted. Field spread of TYLCV followed the logistic model. Symptoms of TYLCV were observed in the third week after transplanting in each plot. Ensuing infections were observed close to the initial loci of infection but also some distance away. Weekly incidence of TYLCV was positively correlated with the weekly flight activity of whiteflies within the plots.

**d. Evaluation and technology transfer IPM packages for aphid-transmitted viruses in pepper in Jamaica.** A study was conducted at the Ministry of Agriculture Experimental Station at Bodles, Old Harbour, St. Catherine, Jamaica. The experimental design was comprised of split plots, one with a corn barrier and the other without a corn barrier. Within each split plot there were random allocations of subplots with single treatments of straw mulch, two neem formulations (NeemX and Azadirect), straw mulch combined with each neem formulation, and a control. Arrangements were made with two farmers in St. Catherine to conduct on-farm evaluation of the impact of selected IPM strategies for management of TEV and other aphid-transmitted viruses in pepper (*Capsicum chinense*). The pepper seedlings were being produced at the end of the reporting period. This experiment will be established in the fields during Year 4.

**e. Aphid-transmitted virus ecology and disease management in Dominican Republic.** Host country scientist T. Martinez visited Jamaica in September 2007 to observe research approaches. Plans were made to trap aphids and to design IPM packages and monitor for virus to assess efficacy of different treatments. An experiment was conducted to examine TEV epidemiology, the main objective being observation of how the disease development occurred during the lifetime of the crop. The experiment was conducted in the Ocoa

Valley, Campo Experimental del Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF). Pepper (*Capsicum annuum*) seedlings were grown under protected conditions to assure virus free plants. Three plots of 209.67m² with 720 plants per plot were planted with a total of 2,160 plants. Nine plate traps (green) were used to catch insects, and were painted to resemble mosaic pattern with yellow paint (at the suggestion given by S. MacDonald, Jamaica). The traps contained water, glycerin, and soap, and were evaluated every week. The first virus-like symptoms appeared 15 days after transplanting with 8% incidence. At 26 days the incidence was 15% and kept increasing, with the highest incidence in the experiment at 60%. Among the insects trapped, 250 specimens were collected from the family Aphididae. Two species were identified by Sardis Medrano, entomology from IDIAF, as *Aphis illinoensis* Shimer (20%) and *Aphis craccivora* Koch (80%). The highest population of aphids was observed at 38 days after transplanting and began to decrease after 55 days. Additional time will be dedicated next year to gathering information. The data are incomplete because of the constant rain that affected Ocoa Valley this year. Fields visited during surveys for virus incidence were also observed for aphids. It is interesting that in fields at la Cienega with less than 5% of TEV symptoms, a parasitoid was found on *Myzus persicae*, suggesting that reducing aphid populations by biocontrol may be an interesting approach in managing these viral diseases.

**f. Evaluation of virus disease management by environmentally friendly mulching approaches.** As part of a trial conducted at CEDEH-FHIA (Comayagua Valley) in Honduras to evaluate the reaction to the locally-present viruses and production performance of a number of varieties of tomatoes, peppers, and cucumbers available in the local market, the planting beds were covered with black plastic mulch in half of the experimental area and the other half was left uncovered. The purpose was to evaluate and validate the effect of mulching the beds on virus disease incidence and severity. In tomato, the average incidence of viral diseases calculated from seven consecutive weekly disease assessments was 48.4% and 28.2 % in bare and mulch-covered beds, respectively. The corresponding mean severity was of 3.0 and 1.9, respectively (scale in which 1 = symptomless and 5 = most severe). A similar response was observed in peppers. There were no recorded viral disease symptoms in cucumbers. Evidently, there was a strong beneficial effect in reducing viral disease incidence and severity as a result of using the plastic mulch.

**Managing viral diseases in vegetables through resistance to economically important insect-transmitted viruses**

**Identifying vegetable varieties with resistance to prevalent viruses**. From websites of various commercial vegetable seed companies, Deom (University of Georgia) collected information on numerous vegetable varieties advertised as having virus resistance. The virus-resistant variety descriptions of vegetables potentially of interest for sites in Honduras and the Dominican Republic, and possibly available locally, were provided to Rivera at FDIA and Roca at Zamorano in Honduras, and to Martinez at IDIAF in the Dominican Republic. The strategy is to identify commercially available virus resistance that might be of interest and that can be purchased locally for testing at the host country sites.

Selections from the AVRDC pepper germplasm collection have also been included in screening for resistance to viruses. Thirty bottle gourd, 25 cucumber, and 306 pepper lines including some with reported geminivirus resistance and randomly selected from the AVRDC germplasm collection were sent by S. Green (AVRDC) to Deom (University of Georgia), who provided selected lines to collaborators in Honduras. AVRDC has also tested lines in Mali.

Bare bed Mulched bed

Tomato cv. Shanty

Figure 5. Reduction of virus incidence in tomato by plastic mulch in Honduras.

**a. Response of local varieties of vegetables and AVRDC germplasm to natural infection with viruses in Honduras.** A trial was established at CEDEH-FHIA (Comayagua Valley) to evaluate the reaction to the locally-present viruses and production performance of a number of varieties of tomatoes, peppers and cucumbers available in the local market. A total of ten commercial varieties of tomatoes, five varieties of cucumbers, and one variety of sweet pepper were transplanted on February 4, 2008 using a randomized complete block design with three replications. The plots were surrounded by a double-row perimeter of sorghum. Among the tomato cultivars, the cultivar Shanty (Hazera, Israel) was remarkable in showing a low incidence and severity of viral diseases. The tomato cultivars Zeus, Comodoro, and Mykonos also showed some degree of resistance, and the varieties Comanche, XP-025, and Tygress were all very susceptible. All of the pepper varieties from AVRDC were susceptible and showed symptoms. None of the cucumber cultivars in the group developed symptoms of viral diseases, which precluded making a reliable evaluation. Evidently, resistance/tolerance to viral diseases plays a major role in reduction of losses and it should be combined with additional measures for viral diseases management, i.e., plastic mulch and others. A total of 59 samples of leaf tissue were collected from symptomatic plants and are being preserved in vials with glycerin within a freezer for future analyses for virus identification.

Two weeks later, 11 experimental lines of peppers from AVRDC were also transplanted into an adjacent plot in the same field in Comayagua. Begomovirus was detected by PCR in 17 out of 19 symptomatic pepper samples. The Comayagua location should be considered for repeating the begomovirus resistance screening in Honduras because of the high virus incidence.

An additional test of 24 AVRDC pepper lines wase conducted at Zamorano. This screening failed because of low virus incidence. A total of only 18 symptomatic plants with severe golden mosaic or mild yellowing symptoms were observed, which included 11 out of the 254 susceptible checks (Keystone), 1/5 of PY1, 1/29 of PY9, 2/51 of PY137, 1/20 of PY169 and 2/23 of PY174 plants. All other plants were symptomless including 30 of PY2, 15 of PY3, 26 of PY7, 14 of PY18, 18 of PY27, 18 of PY33, 18 of PY39, 26 of PY40, 36 of PY75, 21 of PY108, 19 of PY111, 20 of PY112, 25 of PY115, 3 of PY119, 55 of PY130, 48 of PY150, 62 of PY154, 28 of PY165, and 33 of PY168. Begomovirus was detected by PCR in only three out of the18 symptomatic plants using the begomovirus general primers-PAR1c715/PAL1v1978, meaning that only three out of a total of 897 (0.33%) plants were actually infected. Based on the low begomovirus incidence, the trial should probably be repeated next year at a time and in a location where natural disease incidence is higher.

**b. Screening pepper for geminivirus resistance in Mali.** In 2008, 44 pepper lines were screened in Mali in a none-replicated trial. Thirty-four lines were selected from last year's best performing lines in Mali (<20% virus infection including PY No. 3, 5, 9, 10, 22, 30, 33, 110, 126, 135, 143, 147, 150, 155, 156, 163, 204, 219, 237, 254, 267, 270, 277, 282, 296, 297, 301, 304, 309, 320 and 362;

20-45% infection including PY No. 24, 47 and 113), eight lines with reported resistance (PY No. 29, 32, 34, 121, 154, 176, 212 and 287). Two susceptible lines (PY20 and PY207) were also included. Plants were transplanted to the field on January 1, 2008, with 24 plants of the same line per plot. Plots of the local susceptible variety (Gbatakin) were also planted as spreaders for every five test-plots. Virus symptoms were recorded visually on July 16, 2008 using a simplified rating system: 0= no virus symptom; 1= mild yellowing and/or leaf curling; 2= severe symptoms: yellowing, leaf curling and/or stunting. Twenty-one lines with low and high virus incidence based on visual rating as well as 45 plants of the local susceptible check were selected for virus detection by PCR using the begomovirus general primer pair-PAR1c71/PAL1v1978. Virus incidence was determined by: symptomatic plants plus symptomless PCR positive plants/total living plants. The susceptible lines (Gbatakin, PY20, and PY207) showed high virus incidence (77 to 100 %). One of the lines (PY163) had less than 20% infection. In two lines (PY10 and PY30), infection ranged from 20-50%. The remaining 41 lines had more than 50% infection. The relation of visual symptom rating to presence of begomoviruses detected by PCR is shown in Table 2 (pg. 129). The symptom rating 0 and 2 are 80% accurate, whereas symptom rating 1 appears to be only 50% accurate. Some false positives may therefore be included in this rating.

**c. Exploring the use of transgenic resistance to viruses.** Deom (University of Georgia) is completing the "USAID Biosafety Proposal and Reporting Requirements" process for approval for testing transgenic tomato containing resistance to TMV in the field in Honduras. Hopefully, the transgenic tomato screening will be approved and testing will begin in 2009, following approval bythe Honduran Biotechnology and Safety Committee. In Guatemala, the UVG Lab is continuing to explore transgenic resistance as an option for virus management, and has given talks to growers about transgenic crops.

**Stakeholder Acceptance of Virus Management Practices and Outreach**

**Survey of farmer practices in two tomato growing areas in Jamaica.** In gathering the vector population data, it was observed that there were several instances when farmers within these districts did not grow tomatoes for a period of time. It became necessary to determine the reasons for the practice and to see how it would impact future recommendations for management of the TYLCV in these communities. Hence, a survey was conducted in the two parishes in which whitefly population is monitored. The aim of the survey was to examine farming practices by tomato growers in these areas in order to develop appropriate management strategies for TYLCV that would be adaptable by the target farmers. The survey was conducted during August through December 2007 in the parishes of St. Catherine and St. Elizabeth where 57 and 88 tomato farmers were interviewed, respectively.

**Engagement of stakeholder groups in Dominican Republic.** The survey in the Ocoa region of the Dominican Republic clearly showed the extremely high incidence of aphid-transmitted viruses in this location, and an area in which experiments on management of the virus diseases are being conducted. The finding of three viruses in protected production systems has also created a concern. A meeting was coordinated with the Association for the Development of San Jose de Ocoa, (ADESJO), an NGO where various farmers are organized. Out of 43 small greenhouses, 27 are managedby men and the rest by woman. The meeting was with Carlos Bonilla, the coordinator, and other technicians. The IPM-CRSP was explained as well the objectives. They agreed to collaborate with the project in two stages: 1) monitoring survey and 2) implementing strategies of IPM for the control of virus. Carlos Bonilla and others expressed satisfaction to know about the project. This association will be the link to have access to as many farmers as possible.

Table 2. PCR detection of begomovirus in selected pepper plants rated in the three3 symptom categories

| Symptom rating | Total samples no. in the category[1] | No. PCR positive, (%) |
|---|---|---|
| 0 | 110 | 22 (20%) |
| 1 | 231 | 114 (49%) |
| 2 | 176 | 140 (80%) |

[1]by visual symptom observation

**Interactions with grower groups in Guatemala.** In November 2007, the National Seminar of Whitefly and Viral Diseases was held with attendance by 372 growers from the main valleys in Guatemala. In this seminar, the Palmeiri group participated by giving a detailed description of the results for the national whitefly monitoring and the actual achievements of the program. Some pictures from the seminar are presented below.

**Workshops**

**Jamaica:** A farmer field day was held on May 27, 2008 to show the results of the different treatments employed to delay the incidence and/or reduce the effect of tobacco etch virus (TEV) in Scotch Bonnet pepper. A seminar was also presented to the participants on the management of TEV in hot peppers, drawing from information from previous IPM CSRP research activities. The 18 participants included pepper farmers from St. Catherine and Clarendon, extension officers from the local Rural Agricultural Development Authority, and the local Agricultural Support Services Project. Two participants were returning residents seeking to establish their farms.

**Guatemala:** The field supervisor for the whitefly and begomovirus monitoring program was in charge of giving small workshops periodically to growers and field technicians emphasizing the importance of the implementation of IPM strategies for the management of begomoviral infections

**Networking and Collaborations**

Project scientists from Central America and the Caribbean, with the exception of Gilbertson, met in Guatemala City at the University del Valle de Guatemala in December 2007. All participants had the opportunity to present their work since the project's inception, and to discuss future plans. Among the participants was Wen-Shi Tsai, representing Dr. Sylvia Green of AVRDC. A field trip was taken one day to the Salamá Valley where fields of begomovirus-infected tomato were seen. Protection of tomato and pepper in large mesh-houses was also observed.

Collaborators in Africa met in Cameroon in September 2007. In-country scientists (Koutou – Burkino Faso; Leke – Cameroon) are currently receiving advanced training in virus diagnosis in European and U.S. laboratories funded by other sponsors and thus leveraging funding from IPM-CRSP. Discussions are ongoing with the West African site on cooperative research to assess whitefly vector biology and diversity and geminivirus identification, and plans have been made to establish these collaborations in Year 3. Emphasis will be placed on in-region capacity building to process samples and detect geminiviruses and their whitefly vector species and biotypes.

# 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*

**Co-Invetigators:**
Ron Stinner, North Carolina State University
Shelby Fleishcher, Pennsylvania State University
**Host Countries:** Jamaica, Indonesia, Mali, Ecuador
**Collaborators:** Southeast Asia Program, West Africa Program, Latin America and the Caribbean Program, Insect Transmitted Viruses Global Theme.

**Development of decision support tools (to organize, analyze, communicate, and store IPM information)**

On the base built in the first two years, we will continue to develop and link the decision support tools such as databases and expert systems. We have expanded our work to include three major tasks: The Global IPM Technology Database, the West African IPM Network, and the Southeast Asia IPM Network.

**The databases/information systems and other decision support tools**

This project will help enhance capacity in research, training, education, extension, and IPM practice, and also improve communication of pest information among the regions and HCs and expand reach of IPM data and information. It also improves the quality of policy making by providing sound information and efficient communication channels.

**West Africa IPM Network (Whitefly information system)**

A meeting was held at Virginia Tech early in 2008 to discuss revisions of the information system. The new system is being developed to provide more comprehensive information and user-friendly features. We are working with our partners on updating the information and database.

**Southeast Asia IPM Network**

Over 100 linkages have been added to the system. Our work is focused on collecting distribution data of CPB worldwide. A distribution map and reporting system are being developed.

**LAC/Ecuador pest information system**

This GT advises INIAP in developing a national network of IPM information for agricultural products with a number of decision support systems to complement IPM use in the country on main export commodities. INIAP is adding data to the database system.

**Analyze data, model interactions, and provide visualization and communication of results**

GIS, databases, and web application projects for visualization and improved understanding and communication of biotic and economic interactions will be developed through collaboration with RPs, GT, and HC institutions.
The results from this activity will assist communication among scientists, IPM practitioners, growers, and policy makers. It will also help with pest population dynamics, interactions, and biological and non-biological factors regarding agricultural pests and their natural enemies. It will improve understanding of the factors that impact pest population and control outcomes.

**Web, database, and GIS/ interactive cartography integration and applications**

Since the creation of the requirements document (last December), we built pieces that included data collection forms, data definitions, spatial data layers, and interactive cartography tools, and had hoped to have them integrated into a single webpage. Unfortunately, the integration was delayed. The individual pieces are still available as follows:

1. Fruit fly record sheets developed for this project in the field – see attached files.

2. Initial efforts at capturing this into webpages, with metadata capture.
http://www.caribbeanpestwatch.org/cgi-bin/defineCollector.cgi
http://www.caribbeanpestwatch.org/cgi-bin/defineSite.cgi
http://www.caribbeanpestwatch.org/cgi-bin/enterTrapData.cgi
3. Integration of the data into a mapping tool http://www.caribbeanpestwatch.org/tool.html
4. A series of spatial data layers built for this - go into the map tool, click on the active area – Jamaica – and select options within that. Shaded relief map, other data layers, zoom features, etc. With the exception of the initial page showing the Caribbean Basin from which you select an area with this basin, we have only been building spatial data layers for Jamaica.

To get an idea of these pieces working together, see http://www.pestwatch.psu.edu/sweetcorn/tool/tool.html

You might consider this a Pestwatch Version 2.0, built in 2007 as we geo-expanded from ~200 sites to 545 sites. The same data-entry, databasing, and visualization efforts in this effort to build Pestwatch version 2.0 are going into Caribbean Pestwatch. One way to look at this is to realize that we are working with the same part-time programmers on many projects. They invested time on the Caribbean project last winter, transferred to the U.S. project during the spring and field season, then dropped the improvements plan for the U.S. project around mid September and returned to this Caribbean project. I expect the same sort of seasonality to deal with work and budgets.

Data is being uploaded from Jamaica to the system through the online data report system.

We are also developing an internet-based surveillance and mapping application, pestMapper. This intelligent gathering tool is used to address the critical needs in reporting and alerting important pest events such as new pest outbreaks in global and regional bases.

This Google map-based intelligence maps pest occurrence to a global map based on country, pest species, host, and event type (e.g. outbreak, new distribution, etc). Alerting messages can be sent to registered users automatically if certain types of events such as pest outbreaks occur.

Besides viewing geo-distribution, users can also use the application to view the temporal distribution of a biological event.

Data can only be entered through an online data entry system which uses Yahoo web service for automatic geo-coordination withversion one. Version two is an automated, real-time internet surveillance tool for pest intelligence. This application can be used for any geo and temporal distribution.

Development or improvement of information systems/databases will be developed/enhanced in host countries for pest monitoring and GIS capacity building.

**Expected Outputs**

**IT support and capacity building**

Almost all IPM CRSP active programs involve IT and database applications. This GT will provide necessary support and consultation in these programs. At the meantime, this program will conduct some basic programming work for capacity building.

This work will impact all IPM CRSP programs and pest management practices in the HCs and regions in both the short and long run. Specifically, by expanding IT into research and extension programs, this work can improve the efficiency of research and education in the HC and the regions. Secondly, this program will help to bring RP together so that information can be readily shared and any technology developed from an IPM CRSP program can be easily transferred to other regions. Lastly, this program helps RP and HC layout information within the infrastructure for future work.

Hardware and software readiness, database design and metadata definitions, web browsing, and dynamic web programming are important parts of the program.

We have held a number of trainings and workshops in various regions as stated in other parts of the report. Besides, we are working with a number of IPM CRSP programs such as the Virus Global Theme and LAC on a virus database. We are also working with Ecuador to help setup a national pest information system.

The objective was to link to USDA Regional IPM Center information and IPM CRSP reporting.

A number of national and international IPM information systems such as the USDA Regional IPM Center's information system are available. IPM CRSP is expanding its reporting system. This GT will provide links and programming so these key information sites can communicate and link with each other.

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

The Global IPM Technology Database will use web services to seamlessly integrate search functions with both USDA Regional IPM Centers' databases and the IPM CRSP Reporting System.

We have a staff to collect USDA and other U.S. federal, state, and regional pest management links. All international major pest management websites and databases also have been linked to our sites. Our pest linkage might be one of the most comprehensive sites in the world.

Another objective was to assess the impact of this global theme on host countries.

After completion of the assessment, we will have a better idea on how this GT can help HC in terms of information sharing, communications, and infrastructure building. These results will provide us with the knowledge on how we can improve our research and service activities in the future.

**Development of the technique and plan for impact assessment**

The nature of this global theme makes it difficult to evaluate the accomplishments; especially since we are still only in Year 3. We will continue to assess this global theme project throughout Year 4 and thereafter.

# IPM Impact Assessment for the IPM CRSP

*George Norton, Virginia Tech*

**Co-Investigators:**
Philip Pardey, University of Minnesota
Stanley Wood, IFPRI
**Host Countries:** All participating countries of IPM CRSP
**Collaborators:** All IPM CRSP Programs, IFPRI, IRRI, CIMMYT, CSIRO.

**Review impact results across sites and fill in gaps to provide impact assessment summary for the IPM CRSP**
During 2007-2008, one graduate student at Virginia Tech (Atanu Rakshit) completed his M.S. thesis examining the impacts of the pheromone IPM research in Bangladesh. Working with a second student at Virginia Tech, Tatjiana Hristovska, a review of previous impact assessments on the IPM CRSP was conducted and new impact analyses began for plantain in Ecuador and tomato in Uganda and Albania. An overall impact assessment report is near completion.

**Development of consistent and integrated, spatially-referenced, and tabular datasets**
Production, consumption, price, and crop performance data to simulate pest control benefits.

Support from the IPM-CRSP to IFPRI and the University of Minnesota is being leveraged with funding from the Bill and Melinda Gates Foundation to the *HarvestChoice* project co-led by IFPRI and the University of Minnesota. IPM-CRISP funds have enabled HarvestChoice researchers to develop original data sets and new analytical tools designed to assess the productivity impacts of technological (and market) interventions that best address the needs of poor producers (and consumers) throughout the developing world, but with special emphasis in sub-Saharan Africa and south Asia.

The primary use of IPM-CRSP funds has been to support the research assistantship for Ph.D. student Jason Beddow in the University of Minnesota's Department of Applied Economics, and to help facilitate research staff input from IFPRI. In addition to leveraging with funds from the Gates Foundation, additional funding from a University of Minnesota Hueg-Harrison Fellowship has also helped to underwrite the research efforts. In close collaboration with colleagues at IFPRI and other key research partners around the world, this program of work has developing tools and techniques that support spatially explicit assessments of investment in the amelioration or elimination of biotic production constraints (pests) in a spatially explicit framework.

Pest population dynamics, migration, invasion, and damage are driven by local conditions such as temperature and rainfall. Thus, a crucial first step in determining where, whe,n and how agricultural systems might be affected by biotic constraints is to determine the spatial (and temporal) incidence of pests, weeds, and diseases. Unfortunately, there is little data on the spatial occurrence of various pests. What data do exist are of a limited (not global) extent, generally reported at coarse resolutions that are inappropriate for global analyses, and usually lack meaningful geo-spatial coordinates.

Recognizing that much of the necessary pest data are held as tacit rather than published knowledge, often by those with local expertise, one of the project's primary activities has been to develop a new online surveying method and practical tool that allows for rapid and distributed collection of spatial (pest and disease occurrence) data. The result of this effort is the V-GET (Virtual Geo-referenced Elicitation Tool) platform. V-GET incorporates a number of innovations in spatial surveying, such as direct collection of gridded data, and the incorporation of subtle social networking concepts which, together, improve the quality and usability of the survey data by simultaneously assuring data consistency (across respondents and other datasets) and by eliciting responses only from targeted respondents who are likely to provide informed responses. Response rates are improved by displaying a simple and intuitive survey interface (Figure 1) while providing a full suite of survey management tools to survey facilitators. During the past year the design and programming of V-GET was completed and the tool was made operational on the *HarvestChoice* server located at the University of Minnesota.

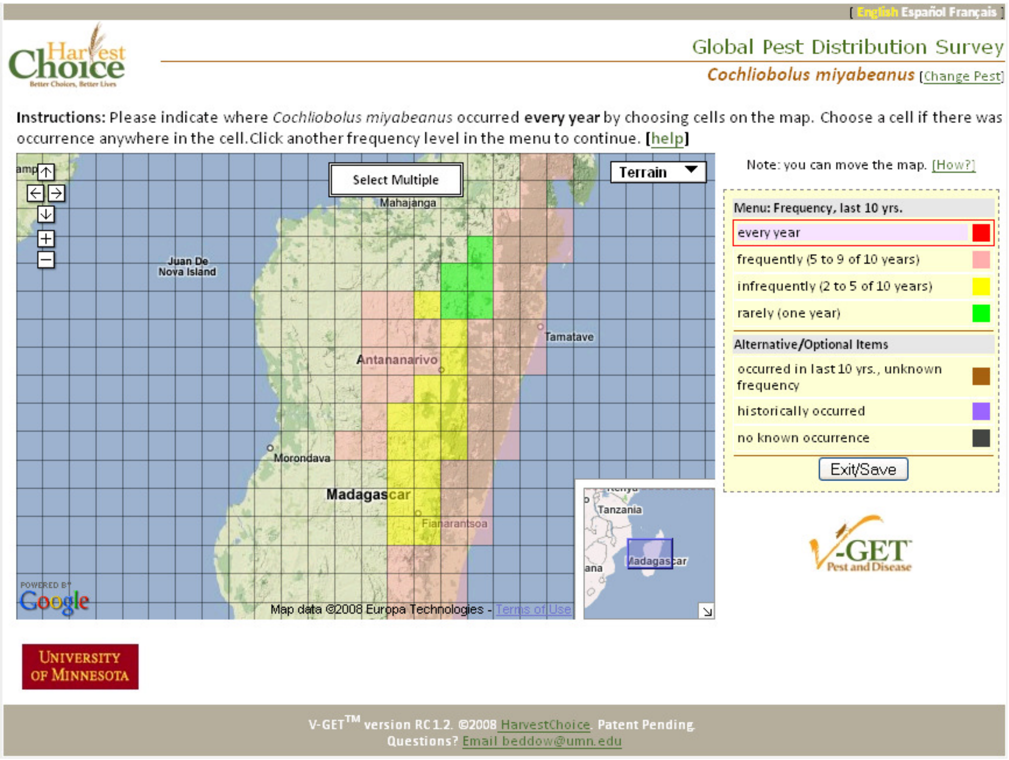



Figure 1: Example V-GET Interface

**Insect and disease surveys**

It is practically impossible (and probably not cost effective) to attempt a globally comprehensive survey of pest and disease occurrence even for a single pest or disease, let alone a range of pests and diseases covering a range of crops. The V-GET surveying approach aims to collect sufficient data across a globally representative agro-ecological gradient to enable accurate calibration of a spatial pest occurrence simulation program (CLIMEX). After deliberations with numerous pathologists, entomologists, agronomist, and other relevant scientists, a target list of survey pests and diseases was compiled (see link at http://www.harvestchoice.org/production/bioticconstraints/mapping.html). A series of international surveys of the spatially-explicit occurrence of specific insects and diseases is underway with the cooperation of co-survey leaders based at CIMMYT, CIAT, IRRI, and CSIRO.

**CLIMEX pest occurrence modeling**

Combining V-GET survey data with information on pest biology gleaned from an ongoing and systematic survey of the technical literature (being conducted jointly with a subject specialist at the University of Minnesota library), a series of global pest occurrence maps are being finalized and over the coming months will be made available via the *HarvestChoice* web site. The CLIMEX modeling tool (developed by a team at CSIRO Australia) is being used to develop spatially explicit maps of the plausible spatial distribution of pests. An example map is presented in Figure 2, showing the distribution of the stalk borer *Chilo partellus*. *HarvestChoice* has contracted Bob Sutherst (University of Queensland) who led the development of CLIMEX to assist in the development of these pest occurrence maps. These maps are being developed jointly with research partners at CIMMYT, IRRI, CIAT and the University of Minnesota. A validation process that solicits input from internationally renowned plant pathologists, entomologists, geographers, and other scientists has also been implemented. The occurrence maps are being released with a version stamp with the notion that as more and better data become available, updated versions of the maps will be released.

**Coupling pests & diseases to plant productivity**

The *HarvestChoice* approach to assessing the productivity and related economic consequences of ameliorating the occurrence of crop pests and diseases is to use "coupling pathways" (e.g., effects on leaf area and mass, stalk diameter, root mass, and so on) that link spatially explicit and pest-specific occurrence (and intensity) information to spatially explicit crop growth models. During the past year a suite of "pixilated" crop growth models was made operational for sub-Saharan Africa (with other areas of the world to follow) and calibration of those models is well advanced. The *HarvestChoice* team is presently experimenting with a range of more-or-less data demanding methods to couple the project's pest and disease platform to the project's crop modeling platform. In addition to this complementary crop modeling work, major investments of time and effort are also being made to develop spatially explicit crop production typographies (regarding planting dates, input use patterns, farm attributes) to further refine and calibrate the project's productivity and economic assessments.

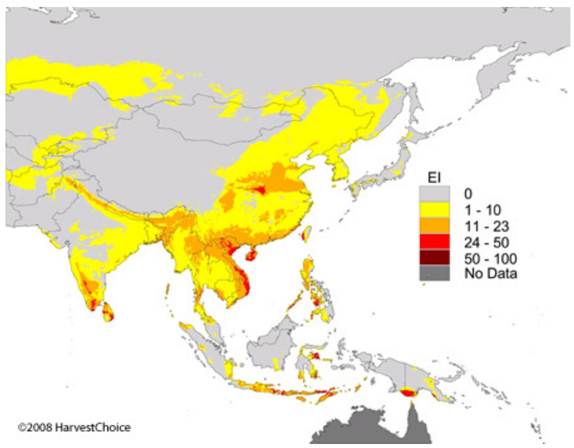



Figure 2: Chilo partellus Ecoclimatic Index in Asia

**Web platform and other outreach activities**

To share data and results and thereby enhance the impact of the *HarvestChoice* project, a major effort was expended during the past year to develop content for the *HarvestChoice* web site (see www.HarvestChoice.org). The biotic constraints work is given special prominence at http://www.harvestchoice.org/production/bioticconstraints/pestsdiseasesweeds.html and the support from (and a back link to) the IPM-CRSP project is located on the following website:
http://www.harvestchoice.org/about/support/support.html.

**Establishment of collaborative relationships**

Over the past year, the Impact Assessment Global Theme had interactions with scientists at several IARCs including CIFOR, CIAT, IRRI, IITA, ICARDA, CIMMYT, and IFPRI.

**Workshop for project scientists on impact assessment**

Collaborating with scientists in the Latin American site, a four-day workshop on (economic and social) impact assessment was held at Zamorano in Honduras with 20 participating scientists from Honduras, El Salvador, Nicaragua, and Ecuador. The workshop, organized with the assistance of the IPM CRSP co-investigator at Zamorano, Alfredo Rueda, was taught through interactive presentations and hands-on activities. There were breakout sessions and a field trip. Participants were instructed in theory and methods for impact assessment, and they left with tools and the knowledge for conducting economic assessments. The workshop follow-up assistance was given on a baseline survey for a scientist at Zamorano.

**Methods and analyses to a broader audience**

A book chapter was drafted with Scott Swinton at Michigan State that provides a protocol for impact assessment. It will be published by CABI in an edited book due out in November 2008. A series of PowerPoint presentations was prepared in Spanish for use in IPM impact assessment.

# Gender Equity

*Maria Elisa Christie, Virginia Tech*

A special gender initiative was included in this year's IPM CRSP activities. At the IPM Symposium held in Manila, Philippines during May 2008, three presentations and panels on gender in IPM CRSP by the gender equity coordinator and IPM researchers served to share experiences and raise awareness of the requirement and relevance of integrating gender in IPM research. The presentations also educated the participants on the difference between assuring and documenting women's participation on one hand, and gathering sex-disaggregated data and undertaking gender analysis on the other. With a view to the future of IPM CRSP, these issues were raised once again in the TC meeting. After the symposium, the gender equity coordinator, Maria Elisa Christie, visited SE Asia program sites in Indonesia and Philippines. Additionally, selected gender and IPM resources were made available online through the IPM CRSP website. A set of research questions was proposed and posted as well. In addition, $35,000 was set aside for gender and participative research and made available to all regional programs. The projects below have been supported by this special gender fund. Planning is underway for a gender and participative methodology workshop to build capacity in West Africa.

**Evaluation of the technology transfer project for plantain farmers in El Carmen, Manabi, Ecuador carried out by INIAP/Pichilingue under the auspices of the IPM CRSP**

Colette Harris, University of East Anglia, UK
Carmen Suarez, INIAP Ecuador (El Instituto Nacional Autónomo de Investigaciones Agropecuarias)
Jeff Alwang, Virginia Tech

Evaluation of a technology transfer project in Ecuador was carried out at the request of the IPM CRSP management team at OIRED/VT. The project was established between 2003 and 2005 to test innovative, transformative education methods that combine theoretical and practical teaching aimed at enhancing farmers' understanding of their environment and as a result empower them to adopt new farming practices. Site visits, interviews, and group discussions were used to evaluate the effectiveness of these methodologies in the transfer of IPM technology to plantain farmers. Results indicate that the methodological approach has had considerable impact on farming techniques and nearly all participants have adopted one or more components of the recommended IPM practices. Neighboring plantain farmers have also adopted the techniques after observation and discussion with participating farmers. Farmers have enjoyed increased yields and quality of fruits. Participant farmers feel more competent and confident as a result of the project's courses.

Significant changes in relation to gender are also evident. Participation of women in one of the IPM groups evaluated has increased from 0to nearly 50%. This has resulted in male participant behavioral changes at group meetings including the elimination of smoking and drinking. The women in attendance are all wives of the men participating. When given the option of having a separate group, the women chose to attend with their men folk in order to learn beside them. As a result, women's work in the plantations has increased and men have begun to welcome their wives' contribution.

**Exploring the influence of gender on tomato production, including pest management, at East Africa Regional IPM CRSP research sites in Mwea, Kenya and Morogoro, Tanzania**

Wairimu Mwangi, Ph.D. Candidate, The Ohio State University
J. Mark Erbaugh, The Ohio State University

Quantitative sex disaggregated data from research sites at Mwea, Kenya and Morogoro, Tanzania were analyzed to determine the influence of gender on tomato production. The analysis allows cross-national and regional comparison on issues including access to resources, division of labor, perception of pest and disease problems, and pesticide use and safety. Preliminary findings indicate the presence of gender differentiation among many of the issues explored.

At both research sites, female farmers were less likely than male farmers to identify extension officers as the most important source of information on tomato production. Similarly, females reported receiving less formal training in pesticide usage and safety, IPM, and insect identification than males. This is reflected in lower levels among female farmers of practicing pesticide safety procedures such as observation of the 12-hour post-application waiting period and secure storage of pesticides.

Differences between sites were also evident. Female farmers at the Kenya site were less likely to keep records than those at the Tanzania site. There were no gender differences within the sites in ownership of knapsack sprayers, however; farmers at the Tanzania site were much less likely to possess one than the farmers at the Kenya site. There also was a much lower rate of training occurrence at the Tanzania site, resulting in a lower level of practicing pesticide safety procedures. Use of inputs such as fertilizers and mulch was comparable across both male and female farmers at each research site.

**Using spatial technology and techniques for mapping gendered spaces associated with tomato production and IPM adoption in East Africa**

Kellyn Montgomery, MSc student, Dept. of Geography, Virginia Tech
Maria Elisa Christie, Virginia Tech

Field data was collected via surveys, interviews, and focus group discussions during July 2008 to identify the gender issues associated with adoption of IPM by tomato producers in the Wakiso District, Uganda. GPS coordinate data was also collected at locations of agricultural inputs, markets, meeting places, and farmers' residences in order to conduct a GIS analysis of spatial factors associated with tomato production such as distance. A final farmer-to-farmer exchange meeting was held with both IPM and non-IPM farmers to encourage technology dissemination. The discussion was led by local IPM tomato farmers to describe IPM techniques and facilitate a dialogue between farmers to address questions and problems they face. This project was carried out in conjunction with the IPM CRSP East Africa program.

Women tomato growers in this region appear to face additional constraints in the adoption of IPM that men do not. The primary issues that limit women are transportation and mobility due to cultural norms limiting their use of motorcycles and bicycles. Because of this, women do not take their product to market by themselves, and thus do not receive the highest price for their tomatoes: they must sell their produce to a middleman at farm gate, essentially hiring transportation. To sell directly at the market, women hire two motorcycle or bicycle taxis, one to carry the merchandise and another to carry them. Women are less likely than men to adopt IPM technologies that enhance production because the gender division of labor requires additional capital for hiring labor for tasks typically done by men such as transportation, clearing land, and retrieving inputs such as water, stakes, mulch, and chemicals. Additionally, since women do not travel to markets to sell their produce, they do not have regular access to new information about tomato varieties and techniques that is commonly found at the marketplace. Similarly, women have less time to visit places throughout the sub-county where IPM information dissemination might occur. Their lack of time is due to their traditional gender roles whereby they are responsible for reproductive activities at home. According to interviews and focus group discussions, men are more likely to travel and have social exchanges.

Another key gender issue in tomato production is the collection of water. Men ride bicycles to water sources and can carry up to four jerrycans of water at once. Women must walk to fetch water and can carry only one jerrycan at once. Women face a significant cultural constraint by not having access to independent transportation by bicycle that has a direct impact on their ability to increase tomato production. The difference for men and women in time-distance to farming inputs is dramatically increased by the cultural taboo related to women operating two-wheeled vehicles.

# IPM CRSP Management Entity Activities

The Virginia Tech Management Entity (ME) provides overall guidance in the management of the IPM CRSP. In December 2007, working with the External Evaluation Panel, the IPM CRSP Evaluation Report of Phase III CRSP Activities was produced. In February 2008, arrangements were made forthe Administrative Review Team's site visits to Virginia Tech, Virginia State University, and Pennsylvania State University. The Administrative Management Team issued its final report on April 30, 2008, and it recommended to USAID that the IPM CRSP be renewed for another five-year term starting in October 2009.

The IPM CRSP workshop was organized May 19-21, 2008 at the Manila Hotel in Manila, Philippines. The workshop was inaugurated by the honorable Kristie A. Kenney, U.S. Ambassador to the Philippines. It was attended by approximately 80 participants from 20 different countries. Topics covered included IPM CRSP success stories, gender in IPM, collaboration between programs, technical and poster presentations, and a field trip to the International Rice Research Institute and the University of the Philippines at Los Baños. Rapporteurs' notes of the workshop and a CD of the 60 posters presented were prepared and distributed. The IPM CRSP Technical Committee meeting was held on May 22 in Manila after the workshop. Another IPM CRSP Technical Committee meeting was held via conference on September 23, 2008.

The IPM CRSP board meeting was held via conference call on April 11, 2008 and another face-to-face meeting was held at Virginia Tech on September 26, 2009. This meeting was chaired by Larry Olsen of Michigan State University and members present were John Dooley, Virginia Tech; Bobby Moser, Ohio State University; Alma Hobbs, Virginia State University; and Robert Hedlund, USAID. The ME prepared booklets of the IPM CRSP list of publications from 1993, final report of the IPM CRSP Phases I and II (1993-2004), IPM CRSP Technical Workplan for FY2009, and IPM CRSP success stories and provided them to the board.

In FY 2008, IPM CRSP secured two Associate Awards. One from the Senegal mission entitled, "Development and promotion of integrated management of mango pests in Senegal" for $400,000 for two years and the second one from EGAT entitled, "IPM CRSP African food security initiative – Quality food production, availability and marketing" for $1,000,000 for three years.

The FY 2008 IPM CRSP core budget was $3,103,200 and estimated leveraged funds are shown in Figure 1. The distribution of funds to different participating countries is shown in Figure 2.

Figure 1: FY 2008 IPM CRSP core budget compared with estimated leveraged funds.

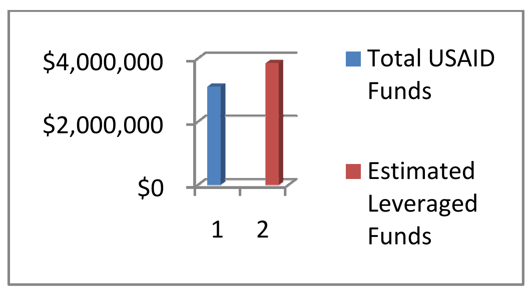
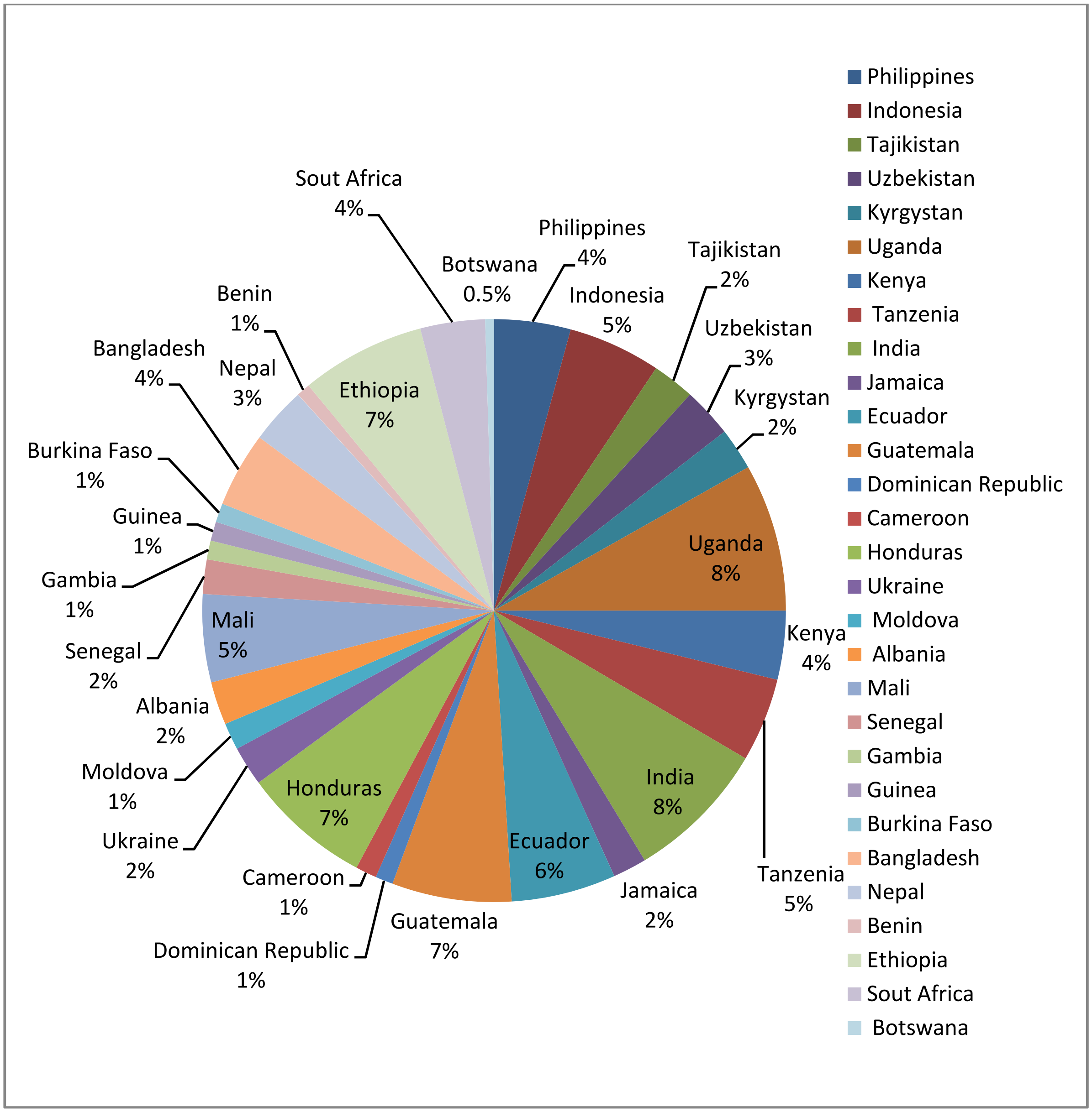


Figure 2: The distribution of funds to different participating countries.



# TRAINING AND INSTITUTIONAL CAPACITY DEVELOPMENT

## Long-Term Degree Training FY2008

All IPM CRSP degree training is closely linked to research activities and aligned with project objectives. Long-term degree training strengthens 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 U.S. universities, the trainingaddresses 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 at both 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.

- Seven U.S. universities, one Swedish university, and 16 host country universities provided long-term training for 62 graduate students (27 Ph.D. and 35 M.S.) and 26 undergraduate students associated with IPM CRSP activities.

- Of these 62 graduate students, 56 are from developing countries and six from the U.S.

- Thirty-eightare men and 24 are women.

- Of the 26 undergraduate students, seven were reported to be women and 14 were said to be men. Sex disaggregate counts were not reported for the remaining seven.

- Their specializations within the graduate program are plant pathology – 10, agricultural economics – 10, agriculture – 9, entomology – 8, IPM – 7, horticulture – 3, crop protection – 3, crop science – 3, plant virology – 2, plant biotechnology – 1, insect pathology – 1, plant ecology – 1, gender issues – 1, weed science – 1, applied economics – 1, geography – 1.

- The number of trainees trained by region is: East Africa – 15, Southeast Asia – 11, South Asia – 9, Central Asia – 9, West Africa – 8, U.S. – 6, Latin America and the Caribbean – 4, and (Table 1 and Appendix I).

Table 1: Long-Term Degree Training Participants by Country, FY2008

| Program | Doctorate | | Masters' | | Total |
|---|---|---|---|---|---|
| | Men | Women | Men | Women | |
| Bangladesh | 2 | | 1 | | 3 |
| Cameroon | 1 | | | | 1 |
| Chili | | | | 1 | 1 |
| Dominican Republic | | | | 1 | 1 |
| Ecuador | | | 1 | | 1 |
| Ethiopia | | | 3 | 1 | 4 |
| India | 2 | 2 | 1 | | 5 |
| Indonesia | 4 | 1 | 1 | 2 | 8 |
| Jamaica | | 1 | | | 1 |
| Kenya | 1 | 1 | 1 | 1 | 4 |
| Kyrgyzstan | | 1 | 3 | 3 | 7 |
| Mali | 1 | | | | 1 |
| Nepal | | | 1 | | 1 |
| Philippines | | 1 | | 2 | 3 |
| Senegal | 2 | | | | 2 |
| Tanzania | | | 2 | 1 | 3 |
| Tajikistan | 2 | | | | 2 |
| Uganda | 2 | 1 | 3 | 2 | 8 |
| USA | 1 | 1 | 3 | 1 | 6 |
| **Total** | **18** | **9** | **20** | **15** | **62** |

## IPM CRSP Degree Training Participants (Graduate Students): FY2008

| Student Name | Sex (M/F) | Nationality | Discipline | University | PhD/MS | Start Date | End Date | IPM Program | Guide/ Advisor |
|---|---|---|---|---|---|---|---|---|---|
| A.K.M. Khorsheduzzaman | M | Bangladesh | Entomology | Bangabandhu Shiekh Mujibur Rahman Agricultural University | PhD | July 2003 | 2007 | Technology transfer, Bangladesh | Zinnatul Alam |
| A.K.M. Salim Reza Mollik | M | Bangladesh | Horticulture | Bangabandhu Shiekh Mujibur Rahman Agricultural University | MS | July2003 | 2007 | Technology transfer, Bangladesh | Mofazzal Hossain |
| Faruque Zaman | M | Bangladesh | Entomology | Penn State University | PhD | Aug 2002 | Dec 2007 | South Asia Regional Program | Edwin Rajotte |
| Leke Walter Nkeabeng | M | Cameroon | Plant Virology | Swedish University of Agricultural Science (SLU) | PhD | 2007 | 2010 | Insect Transmitted Viruses Global Program | Anders Kvarnheden |
| Pilar Jano | F | Chile | Agricultural Economics | Virginia Tech | MS | 2005 | 2007 | Latin America and Caribbean Regional Program | Jeffrey Alwang |
| Xiomara Cayetano Belen | F | Dominican Republic | IPM | Universidad Autonoma de Santo Domingo | MS | 2005 | 2008 | Insect Transmitted Viruses Global Program | Reina Teresa Martinez |
| Robert Andrade | M | Ecuador | Agricultural Economics | Virginia Tech | MS | Aug 2006 | June 2008 Graduated- now working for INIAP/Santa Catalina | Latin America and Caribbean Regional Program | Jeffrey Alwang |
| Kuma Ebissa | M | Ethiopia | Plant Ecology | Haramaya University | MS | | 2008 | Parthenium Global Program | Wondi Mersie |
| Srara Shikur | F | Ethiopia | Gender Issues | Haramaya University | MS | 2006 | 2009 | Parthenium Global Program | Wondi Mersie |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Terefe, Shitaye | M | Ethiopia | Weed Science | Ambo University | MS | 2009 | | Parthenium Global Program | Wondi Mersie |
| Asrese Hussen | M | Ethiopia | Plant Science | Haramaya University | MS | 2006 | 2008 | Parthenium Global Program | Wondi Mersie |
| Sudarsana Poojari | M | India | Plant Virology | Sri Venkateswara University | PhD | Oct 2006 | Sept 2009 | Thrips-borne Tospoviruses Global Program | Naidu Rayapati, P Sreenivasulu |
| Atanu Rakshit | M | India | Agricultural Economics | Virginia Tech | MS | Aug 2005 | June 2007 | South Asia Regional Program, Impact Assessment Global Theme | George Norton |
| Anitha Chitturi | F | India | Entomology | University of Georgia | PhD | 2007 | 2009 | Thrips-borne Tospoviruses Global Program | Riley |
| Rajwinder Singh | M | India | Entomology | Penn State University | PhD | Sept 2006 | Aug 2009 | South Asia Regional Program | Edwin Rajotte |
| S. Sivamani | F | India | Plant Biotechnology | Tamil Nadu Agricultural University | PhD | Oct 2006 | Sept 2009 | Thrips-borne Tospoviruses Global Program | Naidu Rayapati S. Krishnaveni |
| Albert Budiman | M | Indonesia | IPM | Bureau of Agriculture, North Sulawesi | MS | 2005 | 2008 | Southeast Asia Program | |
| Sonya Lumowa | F | Indonesia | IPM | University of Mulawarman | MS | 2005 | 2009 | Southeast Asia Program | |
| Betsy Pinaria | F | Indonesia | Insect Pathology | Sam Ratulangi University | MS | 2005 | 2010 | Southeast Asia Program | |
| Ruly anwar | M | Indonesia | Entomology | Clemson University | PhD | Aug 2002 | Sept 2007 | Southeast Asia Regional Program | Gerald Carner |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Edi Susiawan | M | Indonesia | Entomology | Bogor University | PhD | | 2009 | Southeast Asia Regional Program | Anu Rauf |
| Sonia Lumowa | F | Indonesia | Entomology | Sam Ratulangi University | PhD | 2007 | 2009 | Southeast Asia Program | D.T. Sembel |
| Lukman | M | Indonesia | Crop Protection | Bogor University | PhD | | 2009 | Southeast Asia Regional Program | Amri Jahi |
| Jackson Watung | M | Indonesia | Entomology | Sam Ratulangi University | PhD | Aug 2005 | Aug 2008 | Southeast Asia Regional Program | Dantje Sembel |
| Peta-Gaye Chang | F | Jamaica | Plant Pathology | Virginia Tech | PhD | Aug 2007 | Aug 2009 | Insect Transmitted Viruses Global Program | Sue Tolin |
| Irene Onyango | F | Kenya | IPM | KARI-Thika | MS | | Sept 2008 | East Africa Regional Program | |
| Miriam Otipa | F | Kenya | Plant Pathology | JKUAT | PhD | | Dec 2008 | East Africa Regional Program | Elijah Ateka<br>Edward Mamati<br>Douglas Miano |
| Robert Geisimba | M | Kenya | Horticulture | Ohio State University | PhD | Sept 2006 | Dec 2008 | East Africa Regional Program | D. Struve, R. Mulwa, Egerton |
| Alex Muchina Nduati | M | Kenya | Plant Pathology | Jomo Kenyatta University of Ag | MS | | | East Africa Regional Program | |
| Emil Jekirov | M | Kyrgystan | Agriculture | Kyrgyz Agrarian University | MS | | | Central Asia Program | K. Junusov |
| Ivan Khigai | M | Kyrgystan | Agriculture | Kyrgyz Agrarian University | MS | | | Central Asia Program | Nurali Saidov<br>Janil Chelpakova |
| Kairat Nariev | M | Kyrgystan | Agriculture | Kyrgyz Agrarian University | MS | | | Central Asia Program | Nurali Saidov<br>Janil Chelpakova |
| Aidai Sayakbaeva | F | Kyrgystan | Agriculture | Kyrgyz Agrarian University | MS | | | Central Asia Program | B. Masaitov<br>Murat Aitmatov |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jolpon-Aqbermet Bakirova | F | Kyrgystan | Agriculture | Kyrgyz Agrarian University | MS | | | Central Asia Program | K. Junusov (KAU) Murat Aitmatov |
| Jinara ova Kalibek | F | Kyrgystan | Agriculture | Kyrgyz Agrarian University | MS | | | Central Asia Program | K. Junusov Murat Aitmatov |
| Kiyal Qosimova | F | Kyrgystan | Agriculture | Kyrgyz Agrarian University | PhD | | | Central Asia Program | Dr. Murat Aitmatov |
| Moussa Noussourou | M | Mali | Plant Pathology | University of Mali | PhD | 2003 | 2007 | Technology transfer, Mali | Larry Vaughan |
| Nagendra Subedi | M | Nepal | Plant Pathology | Ohio State University | MS | Sept 2006 | Aug 2009 | South Asia Regional Program | Sally Miller |
| Vida Alpuerto | F | Philippines | Agricultural Economics | Virginia Tech | MS | Aug 2006 | June 2008 | Impact Assessment Global Program | George Norton |
| Myra Clarisse Ferrer | F | Philippines | Applied Economics | Clemson University | MS | Aug 2006 | Aug 2008 | Southeast Asia Regional Program | Mike Hammig |
| Melanie Victoria | F | Philippines | Agricultural Economics | Virginia Tech | PhD | Aug 2005 | March 2009 | South Asia Regional Program | George Norton |
| Kemo Badji | M | Senegal | IPM | University of Theis | PhD | 2008 | 2011 | West Africa Regional Program | A. Maerere |
| Djibril Badiane | M | Senegal | IPM | University of Theis | PhD | 2009 | 2011 | West Africa Regional Program | A. Maerere |
| 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 | Sept 2006 | Oct 2008 | East Africa Regional Program | A. Maerere |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hosea D. Mtui | M | Tanzania | Horticulture | Ohio State University | MS | Sept 2005 | Sept 2007 | East Africa Regional Program | A. Maerere, Mark Bennet |
| Abdulaziz Davlatov | M | Tajikistan | IPM/Ag. | Institute of Zoology and Parasitology of Tajik Academy of Agricultural Science. | PhD | | | Central Asia Program | Dr. Nurali Saidov |
| Tavakal Mirzoev | M | Tajikistan | Agriculture | Institute of Plant Production of Tajik Academy of Agricultural Science. | PhD | | | Central Asia Program | Dr. Nurali Saidov |
| Scovia Adikini | | Uganda | Plant Pathology | Makerere University | MS | | | IITA and East Africa Regional Program | |
| Patrick Kucel | M | Uganda | Crop Protection | Makerere University | PhD | Oct 2006 | Sept 2009 | East Africa Regional Program | S. Kyamanywa, J. Ogwang, J Kovach |
| Sandra Ndagire Kamenya | F | Uganda | Plant Pathology | Makerere University | MS | Oct 2004 | 2007 | East Africa Regional Program | Mark Erbaugh |
| Basil Mugonola | M | Uganda | Agricultural Economics | Virginia Tech | PhD | Aug 2006 | July 2007 | East Africa Regional Program | Dan Taylor |
| Zachary Muwanga | M | Uganda | Agriculture | Makerere University | MS | 2007 | | East Africa Regional Program | |
| Annet Namuddu | F | Uganda | Crop Science/ Crop Protection | Makerere University | MS | June 2006 | Oct 2008 | East Africa Regional Program | S. Kyamanywa, G. Luther, J. Karungi |
| Ben Sekyanzi | M | Uganda | Crop Science/ Crop Protection | Makerere University | MS | Sept 2005 | Oct 2007 | East Africa Regional Program | G. Tusiime, P. Okori, G. Luther |
| Mildred Ochwo-Ssemakula | F | Uganda | Plant Pathology | Makerere University | PhD | | Jan 2009 | East Africa Regional Program | |
| Jessica Bayer | F | USA | Agricultural Economics | Virginia Tech | MS | Aug 2005 | 2007 | Impact Assessment Global Program | George Norton |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jason Beddow | M | USA | Agricultural Economics | University of Minnesota | PhD | Aug 2005 | Feb 2008 | Impact Assessment Global Program | Philip Pardey |
| Steven Buck | M | USA | Agricultural Economics | Virginia Tech | MS | Jan 2005 | May 2006 | Latin America and Caribbean Regional Program | Jeffrey Alwang |
| Michael Castellano | M | USA | Agricultural Economics | Virginia Tech | MS | Aug 2006 | June 2008 | Latin America and Caribbean Regional Program | Jeffrey Alwang |
| Rachel Melnick | F | USA | Plant Pathology | Penn State University | PhD | Sept 2006 | Dec 2009 | Latin America and Caribbean Regional Program | Paul Backman |
| K. Montgomery | | USA | Geography | Virginia Tech | MS | | | East Africa Regional Program | M.E. Christie |

## IPM CRSP Degree Training Participants (Bachelor's Degree Students): FY2008

| Name of the Student | Gender M/F | Program |
|---|---|---|
| R. Trabanino | | Latin American and the Caribbean Regional Program |
| Alicia Joya | F | Latin American and the Caribbean Regional Program |
| A. Rueda | | Latin American and the Caribbean Regional Program |
| A. Pitty | | Latin American and the Caribbean Regional Program |
| D. Cedeño | | Latin American and the Caribbean Regional Program |
| Salvador Canterero | M | Latin American and the Caribbean Regional Program |
| C. Martinez | | Latin American and the Caribbean Regional Program |
| J. Elizalde | | Latin American and the Caribbean Regional Program |
| Felipe Moran | M | Latin American and the Caribbean Regional Program |
| Sandor A. Cruz | M | Latin American and the Caribbean Regional Program |
| Carlos Molina | M | Latin American and the Caribbean Regional Program |
| Nicasio Morán | M | Latin American and the Caribbean Regional Program |
| P. Arnerson | | Latin American and the Caribbean Regional Program |
| Eleazar Dominguez | F | Latin American and the Caribbean Regional Program |
| Zachary Muwanga | M | East Africa Regional Program |
| Agamile Peter | M | East Africa Regional Program |
| Tom Omara | M | East Africa Regional Program |
| Rosemary Namusisi | F | East Africa Regional Program |
| Adolf Saria | M | East Africa Regional Program |
| Anna Baltazari | F | East Africa Regional Program |
| Andrew Elias | M | East Africa Regional Program |
| S. Gabung | F | Southeast Asia Regional Program |
| N. Korompot | M | Southeast Asia Regional Program |
| D. Iriandy Lapasi | M | Southeast Asia Regional Program |
| Edwin Girón | M | Insect Transmitted Viruses Global Program |
| Marcelino Guachambala | M | Insect Transmitted Viruses Global Program |
| **Total** | **26 Students** | |

## Short-Term Training FY2008

During the FY 2008, IPM CRSP held over 153 short-term training events that attracted more than 12,398 participants. IPM CRSP activities were held in 19 different developing countries with the host country collaborators active cooperation. In addition to one survey, 39 workshops, six conferences/seminars, 22 meetings, 24 training sessions, and 61 field days were held to impart various stakeholder technologies (Table 3). Sex disaggregate counts were recorded for most, but not all training events (Table 2). Therefor, the "Total" columns in the following tables may not reflect the reported number of men and women attending.

## Table 2: Short-Term Training Participants by Country, FY2008

| Country | Men* | Women* | Total |
|---|---|---|---|
| Albania | 346 | 77 | **423** |
| Bangladesh | 698 | 1585 | **3213** |
| Central Asia | 81 | 40 | **121** |
| Ukraine | 86 | 42 | **128** |
| Moldova | 56 | 36 | **92** |
| Ecuador | 140 | 29 | **169** |
| Ethiopia | 22 | 0 | **22** |
| El Salvador, Jamaica, and Guatemala | 52 | 25 | **77** |
| Honduras | 204 | 41 | **245** |
| India | 1461 | 687 | **2148** |
| Mali | 8 | 5 | **13** |
| Indonesia | 42 | 22 | **64** |
| Philippines | 1086 | 338 | **1424** |
| Senegal | 3 | 4 | **7** |
| South Africa | 1543 | 1654 | **3197** |
| Uganda, Kenya, Tanzania | 489 | 355 | **894** |
| **Total** | **6317** | **4940** | **12237** |

* Sex disaggregated counts were not made for all training events

## IPM CRSP Non-Degree Training (Participant Summary), FY2008

| Individual Participation to Each Type of Event | Workshops | Training | Meeting | Survey | Field Day/ Demo/ Exhibition | Seminar Symposium Conference | Total |
|---|---|---|---|---|---|---|---|
| **Regional Programs** | | | | | | | |
| **Latin America and Caribbean- Regional Program** | 285 | 169 | 48 | | | | **502** |
| **East Africa – Regional Program** | 101 | 6 | | | 296 | | **403** |
| **West Africa – Regional Program** | 20 | | | | | | **20** |
| **South Asia – Regional Programs** | 32 | 2644 | 259 | | 2234 | | **5169** |
| **Southeast Asia – Regional Program** | 378 | 445 | 98 | 31 | 544 | 113 | **1609** |
| **Central Asia – Regional Program** | 27 | 11 | | | 98 | | **136** |
| **Eastern Europe – Regional Program** | 306 | 42 | 186 | | 350 | | **884** |
| **Global Programs** | | | | | | | |
| **Parthenium Project – Global Program** | 112 | 3 | | | 3006 | 101 | **3222** |
| **IPDN – Global Theme Program** | 26 | 33 | | | | | **59** |
| **Thrips-borne Tospoviruses- Global Program** | 60 | | 15 | | 103 | 160 | **338** |
| **Insect Transmitted Viruses – Global Theme Program** | | | | | 18 | 18 | **36** |
| **Impact Assessment – Global Theme Program** | 20 | | | | | | **20** |
| | | | | | | | |
| **Total Participants at IPM CRSP Events** | **1367** | **3353** | **606** | **31** | **6649** | **392** | **12398** |

**Table 3: IPM CRSP Non-Degree Training (Activity Summary), FY2008**

| Number of Each Type of Event Held | Workshops | Training | Meetings | Surveys | Field Days/ Demos/ Exhibitions | Seminar Symposium Conference | Total |
|---|---|---|---|---|---|---|---|
| **Regional Programs** | | | | | | | |
| **Latin America and Caribbean- Regional Program** | 8 | 3 | 1 | | | | **12** |
| **East Africa – Regional Program** | 4 | 4 | | | 6 | | **14** |
| **West Africa – Regional Program** | 2 | 3 | | | 4 | | **9** |
| **South Asia – Regional Programs** | 1 | 6 | 4 | | 35 | | **46** |
| **Southeast Asia – Regional Program** | 3 | 1 | 5 | 1 | 2 | 1 | **13** |
| **Central Asia – Regional Program** | 2 | 3 | | | 3 | | **8** |
| **Eastern Europe – Regional Program** | 12 | 2 | 11 | | 3 | | **28** |
| **Global Programs** | | | | | | | |
| **Parthenium Project – Global Program** | 3 | 1 | | | 2 | 3 | 9 |
| **IPDN – Global Theme Program** | 1 | 1 | | | | | **2** |
| **Thrips-borne Tospoviruses- Global Program** | 1 | | 1 | | 5 | 1 | **8** |
| **Insect Transmitted Viruses – Global Theme Program** | 1 | | | | 1 | 1 | **3** |
| **Impact Assessment – Global Theme Program** | 1 | | | | | | **1** |
| | | | | | | | |
| **Total IPM CRSP Events** | **39** | **24** | **22** | **1** | **61** | **6** | **153** |

## IPM CRSP Non-Degree Training FY2008

| Program Type | Date | Training Type | Number of participants | Men | Women | Audience |
|---|---|---|---|---|---|---|
| **Latin America and Caribbean- Regional Program** | | | | | | |
| Meeting | Feb 20-22, 08 | FHIA's General Annual Programs Review in La Lima, Honduras | 48 | 44 | 4 | FHIA staff, growers and technicians. |
| Training | | IPM for weeds in horticulture crops- a trimester attended at Perdue University | 2 | 2 | 0 | Students |
| Workshop | Nov 07 | Design on Analysis of Treatments and Experiments in Agriculture Research | 10 | 8 | 2 | Staff of DPP-FHIA |
| Workshop | March 26 and April 02, 08 | Integrated Management of Insects, Nematodes and Diseases of Oriental Vegetables, Comayagua, FHIA | 43 | 41 | 2 | Local Growers and Technicians |
| Workshop | Feb 25-28, 08 | Impact Assessment of IPM Zamorano University | 22 | 10 | 12 | Persons from Nicaragua, El Salvador and Honduras |
| Course | Oct – Dec, 08 | Integrated Pest Management and Good Agricultural Practices at Zamorano University | 110 | 82 | 28 | Zamorano Students from Latin America |
| Course | Aug 07-08, 08 | Safe and Efficacious Use of Agricultural Pesticides. Two day course in Comayagua by FHIA | 57 | 54 | 3 | |
| Workshop | April 21-25 May 19-23, 5-11, 08 | Workshop on management of Frosty pod disease of cocoa | 114 | 105 | 9 | Cocoa producers |
| Workshop | Sept 17-18, 08 | Pest Sample Collection and Diagnostics: Introduction on Phytosanitary Sampling and Field Diagnostic of Pests and Nutritional Disorders of Crops. | 13 | 13 | 0 | CEDA-Comayagua |
| Workshop | July 28-31 | Identification of Immature Insects EET Pichilingue, Quevedo | 27 | 20 | 7 | |
| Workshop | Aug 11-15 | Identification of immature Insects INIAP Pichilingue, Quevedo | 28 | 23 | 5 | INIAP |
| Workshop | Aug 18-21, 08 | Identification of leaf beetles (Chrysomelidae) in Guayaquil Servicio Ecuatoriano de Sanidad Agropecuaria | 28 | 15 | 13 | |
| **Total Participants in the Latin America and Caribbean- Regional Program** | | | **502** | **417** | **85** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **East Africa – Regional Program** | | | | | | |
| Farmer Field School | | Tomato growers IPM practices | 60 | 28 | 32 | Tomato Growers |
| Field Day | | On farm evaluation of Tomato IPM practices from on-station trials<br>Weekly sessions for farmers from two villages | 30 at first 22 on average to weekly sessions | 15 | 7 | Tomato Growers |
| Field Day | | On Station evaluation of IPM practices for Tomato Growers in Tanzania | 20 | 15 | 5 | Tomato Growers |
| Field Day | | Demonstration for the preparation of fresh leaf formulations of neem (*Tephrosia vogelii*) | 27 | 11 | 16 | Smallholder coffee farmers |
| Workshop | | Sustainable Management of *Banana Xanthomonas* wilt outbreaks | 33 | 22 | 11 | District Ag Extension officers, KARI research and tech officers University students from JKUAT and the Provincial Director of Agriculture in Central Province Kenya |
| Field Day | | On farm training on coffee IPM in Shari and Uswaa villages | 138 | 80 | 58 | Village extension officers and members of respective farmer groups |
| Workshop | | Pesticide Safety and Usage Program | 41 | 23 | 18 | Tomato farmers, researchers, and extension agents in Kenya |
| Workshop | | Pesticide Safety and Usage Program<br>Tomato growers competitions to increase dissemination and adaptation of IPM practices | 20 | 14 | 6 | Tomato farmers, researchers and extension agents |
| Field Day | | On farm demonstration in Tomato IPM | 21 | 15 | 6 | Tomato farmers in Uganda |
| Technical Training/ Course | | Harriet Apoo and Thaddeus Kaweesi received training from M. Ochwoh-Smakulu in horticulture. Program was NaCRRI with NARO in the use of molecular techniques for germplasm characterization and virus identification. | 2 | 1 | 1 | Undergraduate students in Horticulture |

| | | | | | | |
|---|---|---|---|---|---|---|
| Technical Training/ Course | | Jesca Mbaka and Sarah Nabulime received training from Geoffrey Tusiime. From KARI in molecular techniques of identifying, culturing and detecting Xcm in banana tissue | 2 | | 2 | Technician in Horticulture |
| Technical Training/ Course | Aug 18-22 08 | Philbert Laureen Kaiza received training from Africano Kangire at the Tanzanian Coffee research Institute (TCRI) on the diagnostics of the coffee wilt disease CWD. IPM CRSP Makerere and NaCRRI. General techniques in idolation culturing, inoculation protocols and management of other diseases including CBD pathogen. | 1 | | | Scientist |
| Workshop | June 30-July 4 | IPDN workshop at Makerere University in Uganda | 26 | 20 | 6 | Scientists from East West and South Africa |
| Workshop | Sept 2-12 | IPDN workshop at OARDC Ohio | 1 | | | Robert Gesimba, Kenyan IPM CRSP co-PI |
| Workshop | Oct 14-16, 2008 | Pesticide Safety Usage Program | 23 | 15 | 8 | Tomato farmers, researchers, extension agents in Kenya |
| Training | | Developing protocols for immunostrip assay for Tomato Spotted wilt virus and Impatiens necrotic streak virus | 1 | | | Ochwo-Ssemakula trained with Naidu Rayapati at Washington State University |
| **Total Participants for the East Africa – Regional Program** | | | **468** | **259** | **176** | |
| | | | | | | |

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|---|---|---|---|---|---|---|
| **West Africa – Regional Program** | | | | | | |
| (3) Pesticide Safety Education courses | | Three pesticide safety education courses were held in West Africa<br>Train the trainer courses that lasted 3 days | | | | OVHN and pesticide safety education instructors |
| 4 Farmer Field Schools | | Farmer Field Schools included IPM training to farmers and pesticide safety education programs within | | | | |
| Quechers work-sessions | | These work-sessions were held at the Env. Toxicology Quality Control laboratory (ETQCL) in Bamaco, Mali | 13 | 8 | 5 | ETQCL |
| Quechers work-sessions | | Work-sessions were held at CERES in Dakar, Senegal | 7 | 3 | 4 | CERES |
| **Total Participants for the West Africa – Regional Program** | | | **20** | **11** | **9** | |
| | | | | | | |
| **South Asia – Regional Program** | | | | | | |
| | | | | | | |
| Workshop | May 7-9, 2008 | Integrated Vegetable Grafting Technology in Tamil Nadu Ag. University India | 32 | 14 | 18 | IPM Scientists, TNAU, and IPM CRSP consultant |
| Field Day | July 7 2008 | Demonstration on identification of eggplant diseases. In Kollupatti, Dharmapuri district in Tamil Nadu India | 26 | 23 | 3 | IPM CRSP team TNAU scientists and farmers |
| Training | 2007-2008 | Transfer of IPM technologies | 1036 | 25 | 1011 | PNGO staff and farmers |
| Field Days (3) | | Demonstration on three IPM technologies in farmers' fields of four districts of Jamalpur, Madaripur, Faridpur and Rajbari.<br>Fruit fly control in cucurbit crops using pheromone bait traps<br>Soil amendments practices with mustard oil-cake (MOC)<br>Cultivation of grafted eggplant and tomato. | 308 | 227 | 81 | Practical Action Bangladesh, farmers, and PNGO staff |
| On Farm Training | July 9 2008 | Meeting with vegetable nursery owners in Divya Nursery, Thondamuthur, Coimbatore, Tamil Nadu India | 14 | 5 | 9 | IPM CRSP team, TNAU scientists and vegetable nursery owners |

| | | | | | | |
|---|---|---|---|---|---|---|
| Farmers Meeting | Nov 16, 2007 | Farmers Meeting regarding training of tomato IPM at the village Tatarpur in India | 57 | 45 | 12 | Tomato Farmers TERI scientists and extension workers |
| Farmers Meeting | Oct 16, 2007 | Farmers Meeting regarding the training of Eggplant IPM at the village Bhoorgarhi in India | 45 | 38 | 7 | Eggplant Farmers, TERI scientists Mahyco Scientists and local villagers |
| Farmers Meeting | Oct 27, 2007 | Farmers Meeting regarding training of Tomato IPM at village Redihalli | 77 | 42 | 35 | Tomato farmers, local villagers and farmers of nearby villages, and TERI scientists |
| Field Days (28 all together) | 22 days throughout 2007 and 2008 | Field Days to teach farmers about IPM technology and its components in India | 1600 | 1100 | 500 | Farmers in India |
| Training | 2007-2008 | IPM technologies for vegetable cultivation | 300 | 210 | 90 | NGO staff and farmers |
| Field Days (3) | 2008 | IPM technologies disseminated to Debidwar of Comilla (May 8), Shekerkhola of Bogra (May 25), and Nangorpur of Jessore (June 28). | 300 | | | Local farmers, extension workers, research personnel, leaders and governemtn officials and the executives of the agriculutral ministry. |
| Training | 2007-2008 | IPM technologies for vegetable cultivation | 630 | | | Field officers and farmers |
| Training | | Practical Action Training on different IPM technologies | 639 | 236 | 403 | NGO staff and farmers |
| Grafting Training | May 1-3, 2008 | Training workshop for eggplant farmers on Integrated vegetable grafting technology for managing soil born diseases and increasing tolerance to flooding in the hot wet season. | 25 | 20 | 5 | Eggplant farmers |
| Farmers Meeting | April 22, 2008 | Farmer meeting regarding IPM training of effective use of pheromone traps and biopesticides in tomato and okra field | 80 | 70 | 10 | On-farm farmers meeting in Bangalore. |
| **Total Participants South Asia Regional Programs** | | | **5169** | **2055** | **2184** | |
| | | | | | | |
| **Southeast Asia – Regional Program** | | | | | | |
| Meeting | April 2008 | Proposal of a demonstration plot in the "swamp" area to provide a safe area for farmers to try good | 40 | 25 | 15 | WSU/USAID, OMG, OPAG, DA, BPI, FPA, BSU-All agencies, and |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | farming practices overseen by experts from all cooperating agencies. Introduced the cooperative idea to all agencies and governor Fongwan. | | | | Governor Fongwan |
| Meeting | Aug 2008 | Interagency meeting to establish demo farm – Site identification | 8 | 6 | 2 | OPAG, OMAG, DA,BSU, WSU/USAID |
| Training | 2008 | Mass production of VAM and *Trhichoderma* sp. Taught to farmers and stakeholders in 22 barangays in 13 municipalities. | 445 | 329 | 116 | Farmers and stakeholders |
| Meeting | Aug 27 2008 | Pre-orientation meeting on organic based strawberry production. Project objectives explained to farmers. 13 Cooperative farmers agreed to terms and conditions of the project. | 18 | 15 | 3 | BSU, WSU/USAID, OMG, OPAG, 11 farmer cooperators |
| Workshop | Sept 5 2008 | Explanation of organic based strawberry production.<br>OMAG and OPAG will provide soft loan to farmers to augment start-up capital.<br>BSU will help in marketing of fresh strawberries to high-end markets.<br>Irrigation water will be purified using carbonized rice hulls.<br>DA will provide clean planting materials for nursery propagation.<br>WSU/USAID, OPAG, OMAG will spearhead mass rearing and field releases of predatory mites. | 29 | 23 | 6 | BSU, WSU/USAID, OMG, OPAG and 14 farmers. |
| Survey/ Project Inter-agency pilot project on organic based strawberry production | Sept 16, 2008 | Distinction made between approaches: organic production or organic based production.<br>Farmers prefer organic based production and positive response on the use of predatory mites. | 31 | 26 | 5 | BSU, WSU/USAID, OMG, OPAG, BPI, DA and 13 farmer cooperators. |
| Field Day | Sept 24, 2008 | Municipal wide information campaign Oplan Sagip Sibuyas in Bayambang, Pangasinan on themanagement of common pests and diseases in | 401 | 312 | 89 | Onion-rice farmers, extension workers, municipal and barangay officials, and |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | rice-onion farming systems. Launchec in collaboration with PhilRice-IPM CRSP and local governments. | | | | students. |
| Technical Briefing | 2008 | Briefings in preparation of FFS to create awareness among farmers the availability of alternative approaches to current pest management practices. | 113 | 91 | 22 | Agricultural Technologists |
| Workshop | Oct 1, 2007 to Sept 30, 2008 | Ten training workshops at barangay level and municipal level | 322 | 246 | 76 | Farmers, extension workers, and agricultural technologists |
| Farmer Field Schools (5 total) | 2008 | IPM on onion conducted in Nurva Ecija and Ilocos Region coordinated with LGU and agricultural Technologiests concerned | 143 | 108 | 35 | Farmers and technologists in the region |
| Workshop | Oct 3, 2008 | Upgrading of OTOP products coming from the proposed interagency demo.<br>Processors demand good quality fresh strawberries to be processed into wines, jams, cakes and cosmetics.<br>Farmer leader assured processors they will follow GAP to meet their demands. | 27 | 2 | 25 | OMAG, farmer leader, DTI, 20 processors headed by Mrs. Maria Que |
| Meeting with farmer cooperators | Oct 4 2008 | Documentation of farming activities.<br>Hauling and distribution of compost.<br>Signing of MOA regarding capital augmentation to be provided by the LGU of La Trinidad. | 15 | 14 | 1 | OMAG, 13 farmer cooperators |
| Meeting/Farmer Leader Training | | Farmer Leader Training was conducted to teach farmers of N. Sulawesi skills required to produce SeMNPV of the beet armyworm and production techniques for *Trichoderma*. | 17 | 10 | 7 | Farm leaders |
| **Total Participants in the Southeast Asia – Regional Program** | | | **1609** | **1207** | **402** | |
| | | | | | | |
| **Central Asia – Regional Program** | | | | | | |
| Training | Mar 2006 to present | Research and Extension Fellows | 3 | 2 | 1 | Research and Extension Fellows |
| Student Field School | Nov 2007 to present | Students from the Kyrgyz Agrarian University | 6 | 3 | 3 | Students from the Kyrgyz Agrarian University |

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|---|---|---|---|---|---|---|
| Training (Postgrad) | Nov 2007 to present | Research on Habitat Management for biological control | 2 | 1 | 1 | |
| Workshop | Feb 27, 2008 | IPM Workshop | 15 | 14 | 1 | |
| Farmer Field School | Feb – June 2008 | IPM CRSP Farmer Field School, season long activities/Tajikistan | 15 | 2 | 13 | |
| Training (Undergrad) | Feb 2008 to present | Undergraduate Research Project for Students from the Kyrgyz Agrarian University | 6 | 3 | 3 | Students from the Kyrgyz Agrarian University |
| Workshop | June 30, 2008 | Tomato Pest Management | 12 | 4 | 8 | Tomato Farmers |
| Farmer Field School | Aug 29-31, 2008 | Advisory Training Center-FFS, Field Day Kyrgyzstan | 77 | 60 | 17 | |
| **Total Participants in the Central Asia – Regional Program** | | | **136** | **89** | **47** | |
| **Eastern Europe – Regional Program** | | | | | | |
| Workshop | Jan 26, 2008 | The new technologies of nematode control (soil solarization) in cooperation with the Albanian Agriculture Competitiveness Project | 35 | 31 | 4 | Farmers, extension officers and specialists of vegetable growing |
| Workshop | 2008 | Farmer group workshop on botrytis in Albania | 10 | | | Farmers |
| Workshop | 2008 | Farmer group workshop on Fungicides for botrytis in Albania | 10 | | | Farmers |
| Workshop | Feb 2, 2008 | Soil Solarization | 16 | 14 | 2 | Farmers |
| Workshop | Feb 9, 2008 | Soil Solarization with nematicides for root knot nematodes. Held in cooperation with the Albanian Agriculture Competitiveness Project | 20 | 18 | 2 | Farmers and vegetable producers from different villages |
| Workshop | Feb 10, 2008 | Workshop on soil solarization | 6 | | | |
| Workshop | Feb 28, 2008 | Workshop on nematicides on pepper in Hysgjokaj Albania | 45 | 39 | 6 | Farmers in Albania |
| Workshop | March 20-22, 2008 | Statistics and GIS – the use of BioClass GIS classification software | 38 | 15 | 23 | Producers |
| Training course | March 28 | The new control methods of tomato and cucumber in greenhouses | 17 | 15 | 2 | Greenhouse growers from several different villages |
| Training course | May 22, 2008 | The new control methods of tomato and cucumber in greenhouses | 25 | 19 | 6 | Greenhouse growers from several different villages |

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|---|---|---|---|---|---|---|
| Meeting | March 24, 2008 | Meeting with Farmers from Moldova: plant protection specialists talked about biological control methods. | 24 | 14 | 10 | Farmers |
| Meeting | March 28, 2008 | Presentation of the main pests and diseases of tomato observed in greenhouses. Part of the Albanian Agriculture Competitiveness Project. | 17 | 15 | 2 | Specialists, farmers and extension officers |
| Meeting | March 30, 2008 | IPM team members and farmers met in Dnipropetrovsk | 9 | 8 | 1 | IPM team members and farmers |
| Meeting | April 3 2008 | Presentation of the main pests and diseases of tomato observed in greenhouses. Part of the Albanian Agriculture Competitiveness Project. | 25 | 20 | 5 | |
| Meeting | April 27, 2008 | Meeting in Hysgjokaj Albania with tomato farmers | 25 | 21 | 4 | |
| Meeting | April 29, 2008 | Second working meeting with IPM team members and farmer in Dnipropetrovsk on insects and biological protection measures for tomatoes and cucumbers. | 6 | 6 | 0 | IPM team members and farmers |
| Poster Presentation | May 19-22, 2008 | Solarization and soil-borne fungi | 80 | 60 | 20 | People who were present at the IPM CRSP meeting in the Philippines |
| Poster Presentation | May 19-22, 2008 | Soil Solarization | 80 | 60 | 20 | People who were present at the IPM CRSP meeting in the Philippines |
| Workshop | May 22, 2008 | New Techniques and methods to control spider mites | 25 | 19 | 6 | Farmers, technicians, extension officers, from 3 villages of the district of Shkodra |
| Meeting | April 25, 2008 | Meeting with tomato farmers in Kosmac Shkoder Albania | 25 | 19 | 6 | Tomato farmers |
| Meeting | June 2008 | Meeting with Farmers in Moldova IPM in greenhouses, Ialoveni district | 11 | 7 | 4 | Farmers |
| Meeting | July 12, 2008 | Meeting with Farmers in Moldova: Crop protection tactics in greenhouses. Ialoveni district | 22 | 10 | 12 | Farmers |
| Workshop | Aug 6, 2008 | Workshop in Lviv/Odesa on "Apple- A commercial crop in Ukraine" | 68 | 37 | 31 | Farmers, farm specialists, scientists and representatives |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | of supermarkets. |
| Meeting | Aug 2008 | Meeting with Farmers in Moldova: Ecologically safe methods for vegetable protection | 10 | 6 | 4 | |
| Workshop | Aug 25, 2008 | Workshop in Lviv/Odesa | 21 | 13 | 8 | |
| Meeting | Sept 1, 2008 | Third working meeting with IPM team members and farmer in Dnipropetrovsk on solving problems in order to get sustainable tomatoes and cucumbers yields. | 12 | 11 | 1 | IPM team members and farmers |
| Poster Presentation | Sept 1-3, 2008 | The monitoring of vegetable aphids at the Third-meeting of the Institute of Alba-Shkenca, Tirana 2008 | 190 | 150 | 40 | |
| Field Workshop | Sept 23, 2008 | Results of field studies on management of whiteflies on tomato crops | 12 | 11 | 1 | Agriculture technicians and farmers |
| **Total Participants in the Eastern Europe – Regional Program** | | | **884** | **638** | **220** | |
| **Parthenium Project – Global Theme** | | | | | | |
| Conference | Oct 2-6, 2007 | 21st Asian Pacific Weed Science Society conference (APWSS) Colombo Sri Lanka | 1 | 1 | 0 | Senior weed scientist from EIAR |
| Capacity Building Training | 2007 | Data collection methods and greenhouse studies | 3 | 3 | 0 | Students in ARD's professional Development Program from Cedara Research Station. |
| Workshop | May 19-21, 08 | Management of Weed Parthenium at the IPM CRSP Annual Workshop: Advancing Regional and Global Theme Programs, Manila, Philippines | 2 | 1 | 1 | Need information |
| Symposium | Sept 18-21, 07 | Southern African Wildlife Management Association Symposium, Didima Camp – uKhahlamba-Drakensberg Park. South Africa | 60 | 42 | 18 | |
| Workshop | Oct 12, 2007 | IPM CRSP Parthenium Project Partners Workshop, Addis Ababa, Ethiopia | 22 | 22 | 0 | |
| Landowners' day | March 19, 08 | Biological control of Parthenium hysterophorus. Pongola/Nongoma landowners' day. South Africa | 30 | 28 | 2 | Landowners |
| Workshop | May 6-9, 08 | 36th Annual workshop on the Biological Control of Alien Invasive Plants in South Africa, Goudini Spa, | 88 | 42 | 46 | Delegates |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Rawsonville. Western Cape, South Africa. | | | | |
| Seminar Series | July 11-15, 08 | Biological control of parthenium and pom pom weed in South Africa. University of KwaZulu-Natal, School of Biological and conservation Sciences. Pietermaritzburg, South Africa. | 40 | 28 | 12 | Staff and students |
| Exhibition | July 11-15, 08 | Biological control of Invasive Plants KwaNunu Exhibition, Durban Natural Sciences Museum, Durban, South Africa. | 2976 | 1400 | 1576 | Members of public and groups of school children (746 learners, 43 educators and 2187 members of public) |
| **Total Participants for the Parthenium Project – global themes** | | | **3222** | **1567** | **1655** | |
| **IPDN – Global Theme** | | | | | | |
| | | | Total | Male | Female | |
| Workshop/ Training Course | June 30-July 4 | IPDN workshop at Makerere University in Uganda: A 5-day training course on identification of the major pathogen and insect pests groups important in agricultural production and trade in East and Southern Africa. The program included lectures, hands-on lab training and sessions on distance diagnosis, communication and networking. | 26 | 20 | 6 | Scientists from East, West, and South Africa |
| Course | | A five day training course in fungal plant pathogens, diagnostic networks, plant nematodes, plant viruses, bacteria digital diagnostic and communications systems, plant parasitic insects and development of SOPs for plant diagnostics. | 33 | 26 | 7 | Diagnostic personnel from Honduras, El Salvador, Jamaica, and Guatemala. |
| **Total participants in the Impact Assessment – Global Theme Program** | | | **59** | **46** | **13** | |
| **Thrips-borne Tospoviruses – Global Theme** | | | | | | |
| Symposium | Oct 15-19, 2007 | 10th International Plant Virus Epidemiology Symposium: Controlling Epidemics of Emerging and Established Plant Virus Diseases – The Way Forward (India) | 160 | 110 | 50 | |
| Meeting | Dec 8-12, 07 | Annual Meeting of the Entomological Society of America (USA) | 15 | 10 | 5 | |

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|---|---|---|---|---|---|---|
| Workshop | May 19-22, 08 | Advancing Regional and Global IPM CRSP Programs, IPM CRSP Workshop (Philippines) | 60 | 40 | 20 | |
| Field Day | June 30, 08 | Field Day, Meerut, India | 15 | 10 | 5 | |
| Field Day | July 3, 08 | Field Day, Hyderabad, India | 15 | 10 | 5 | |
| Field Day | July 7, 08 | Field Day, Kolar, India | 8 | 3 | 5 | |
| Field Day | July 9, 08 | Field Day, Salem | 45 | 15 | 30 | |
| Field Day | July 10, 08 | Field Day, Dharmapuri | 20 | 10 | 10 | |
| **Total Participants for Thrips-borne Tospoviruses- Global program** | | | **338** | **208** | **130** | |
| **Insect Transmitted Viruses – Global Theme** | | | | | | |
| Farmer Field Day | May 27 2008 | Demonstration to show the results of the different treatments employed to delay the incidence and/or reduce the effect of tobacco etch virus (TEV) in Scotch Bonnet Pepper. In Jamaica. | 18 | 11 | 7 | Pepper farmers from St. Catherine and Clarendon, extension officers from RADA and ASSP. |
| Seminar | May 27, 2008 | Presented on the management of TEV in hot pepper in Jamaica | 18 | 11 | 7 | Pepper farmers from St. Catherine and Clarendon, extension officers from RADA and ASSP. |
| Workshop | | Importance of the implementation of IPM strategies for the management of begomoviral infections in whitefly and begomovirus monitoring program | | | | Growers and field technicians |
| **Total Participants for the Insect Transmitted Viruses – Global Program** | | | **36** | **22** | **14** | |
| **Impact Assessment – Global Theme** | | | | | | |
| Workshop | 4 days | Collaboration with Latin America and the Caribbean on Economic and Social Impact Assessment. Was held in Honduras at Zamorano | 20 | | | 20 scientists from Honduras, Ecuador, and El Salvador, Nicaragua |
| **Total Participants in the Impact Assessment – Global Theme Program** | | | **20** | | | |
| **TOTAL PARTICIPANTS FOR IPM CRSP ACTIVITIES** | | | **12463** | **6519** | **4935** | |

*Reported in East Africa Regional Training Section

Sex disaggregated counts were not made for all training events.

**Summary of Participants for IPM CRSP Activities**

| Program | Total | Men | Women |
|---|---|---|---|
| Latin America and Caribbean- Regional Program | 502 | 417 | 85 |
| East Africa – Regional Program | 468 | 259 | 176 |
| West Africa – Regional Program | 20 | 11 | 9 |
| South Asia Regional Programs | 5169 | 2055 | 2184 |
| Southeast Asia – Regional Program | 1609 | 1207 | 402 |
| Central Asia – Regional Program | 136 | 89 | 47 |
| Eastern Europe – Regional Program | 884 | 638 | 220 |
| Parthenium Project – global themes | 3222 | 1567 | 1655 |
| Impact Assessment – Global Theme Program | 59 | 46 | 13 |
| Thrips-borne Tospoviruses- Global program | 338 | 208 | 130 |
| Insect Transmitted Viruses – Global Program | 36 | 22 | 14 |
| Impact Assessment – Global Theme Program | 20 | | |
| **TOTAL PARTICIPANTS FOR IPM CRSP ACTIVITIES** | **12463** | **6519** | **4935** |

Sex disaggregated counts were not made for all training events

## IPM CRSP Funding and Leveraged Funds on Behalf of IPM CRSP Activities

| IPM CRSP FUNDING | |
|---|---|
| **Total USAID Funds** | $3,103,000 |
| **Total Leveraged Funds** | $3,845,325 |
| **Total IPM CRSP Funding** | **$6,948,325** |

## IPM CRSP Publications, Presentations, Posters and Abstracs (Summary)

| | Publications | Presentations | Posters | Abstracts | Total |
|---|---|---|---|---|---|
| **Regional Programs** | | | | | |
| **Latin America and Caribbean- Regional Program** | 11 | 6 | | | **16** |
| **East Africa – Regional Program** | 30 | 7 | 9 | | **46** |
| **West Africa – Regional Program** | | | | | |
| **South Asia – Regional Programs** | 5 | | | | **5** |
| **Southeast Asia – Regional Program** | 3 | | | | **3** |
| **Central Asia – Regional Program** | 19 | 6 | | 56 | 81 |
| **Eastern Europe – Regional Program** | 7 | | | | **7** |
| **Global Programs** | | | | | |
| **Parthenium Project – Global Program** | 6 | 9 | 1 | | **16** |
| **IPDN – Global Theme Program** | | | | | |
| **Thrips-borne Tospoviruses- Global Program** | 3 | 6 | | | **9** |
| **Insect Transmitted Viruses – Global Theme Program** | 3 | 14 | 5 | | **22** |
| **Impact Assessment – Global Theme Program** | 11 | | | | **11** |
| **Applications of Information Technology and Databases in IPM in Developing Countries and Development of a Global IPM Technology Database** | 3 | | | | **3** |
| **IPM CRSP Management Entity** | 1 | | | 3 | **4** |
| **IPM CRSP Conference in Manila** | | | 51 | | |
| | | | | | |
| **Total** | **105** | **48** | **66** | **59** | **227** |

# IPM CRSP Publications, Presentations, and other Products FY2008

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

**Publications:**

Effect on growth, yield and soil-borne disease incidence and severity on tomato, bell pepper and cucumber of the application of the antagonistic fungus *Trichoderma* sp and the mycorrhizal fungus *Glomus* sp to plant roots as biological pesticides. A technical report was written and published in the 2007 annual report of FHIA's Program on Horticultural Crops.

Evaluation of resistance of cacao genetic material to Black pod and Frosty pod rot using artificial inoculations. A technical report was written and published in the 2007 annual report of FHIA's Program on Cacao and Agroforestry.

*Insect pest identification manual.* 2008. Second edition. 4000 copies full color of this 90 pages manual. L Lastres and H Arguello Zamorano

Melnick, R.L., Hidalgo, K.S., Suárez, C., and Backman, P.A. 2008. Field evaluation of endophytic endospore-forming bacteria with cacao successions for management of witches' broom of cacao during the dry season, 2007. Plant Disease Management Reports 2:V136.

Melnick, R.L., Zidack, N.A., Bailey, B.A., Maximova, S.N., Guiltinan, M.J., Backman, P.A. 2008. Bacterial endophytes: *Bacillus* spp. from vegetable crops as potential biological control agents of black pod rot of cacao. Biological Control. 46:46-56.

Melnick, R.L, Suárez, C., Vera, D.I., Bailey, B.A., Backman, P.A. 2008 Endospore-forming bacterial endophytes of cacao: Ecology and biological control of witches' broom. APS Annual Meeting abstract. Phytopathology 98:S104

Management of eggplant fruit borer. Publication of 1000 color hard copies of the fact sheet on "The eggplant fruit borer, *Neoleucinoides elegantalis*" (enclosed attachment), prepared by H. Espinoza (Entomologist).

Management of white grubs. In September was finalized the fact sheet "Advances in the study of the biology and habits of the white grubs (*Phyllophaga obsolete*) in Honduras" (enclosed attachment), prepared by H. Espinoza (Entomologist). It will be reproduced in B&W hard copies the coming year for distribution to growers and other interested parties.

Pests of Oriental Vegetables. As part of a production guide, staff of the DPP prepared a 69-page draft of the "Pests and and Diseases" that in Honduras most commonly attack the general group of crops known as oriental vegetables, which includes a range of exotic cucurbits (Karela, Bitter melon, Fuzzy squash, Tindora, etc.) and eggplants (Thai, Hindu, Chinese, etc.) produced for export to the United States. A final version is expected to be available by year end.

Post-harvest deterioration. Publication of 1000 black and white hard copies of the fact sheet "Post-harvest deterioration of fresh fruits and vegetables by fungi and bacteria" (enclosed attachment), prepared by J. M. Rivera C. (Phytopathologist).

Use of soil solarization for the control of Rhizoctonia root rot of beets in La Esperanza, Intibucá. A technical report was written and published in the 2007 annual report of FHIA's Program on Horticultural Crops.

**Presentations:**

Cerón C. 2005. Estudio del comportamiento y control químico de *Neoleucinodes elegantalis* (Lepidóptera: Pyralidae), Barrenador del fruto de la naranjilla (*Solanum quitoense* Lam.) La Celica, Pedro Vicente Maldonado. Pichincha, Tesis de grado de Ingeniero Agrónomo, Universidad Central del Ecuador. Quito.

Co-colonization of *Theobroma cacao* seedlings with bacterial and fungal endophytes. October 2007. American Phytopathology Society Northeastern Division Meeting

Endospore-forming bacterial endophytes of cacao: Ecology and biological control of witches' broom. July 2008. American Phytopathology Society Annual Meeting

Gallegos P, Arroyo M, Asaquibay C. 2007. Formas de control de *Neoleucinodes elegantalis* en el cultivo de naranjilla (*Solanum quitoense* Lam). Informe anual del DNPV. EESC- INIAP. Quito, Ecuador.

Studies on the suppression of cacao diseases with native endophytic *Bacillus* spp. Penn State University Department of Plant Pathology, Departmental Seminar.

Three training events about IPM in naranjilla were given in three farmers´ communities near by Tandapi in Pichincha province. Also, grafted naranjilla plants were planted there.

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

**Publications:**

Agamile, P. 2008. Options for management of insect pests, diseases and nematodes of hot pepper (*Solanum chinense*) in Uganda. *BSc Special Project Report, Makerere University.*

Amata, R. L., Otipa, M. J Wabule, M., Erbaugh, M., Miller S., Kyamanyua S., Kinoti, J. Incidences and Severity of Passion fruit fungal diseases in major production A paper submitted for publication to the African Journal of Horticultural Science.

Amata, R. L., Otipa, M. J., Wabule, M., Kinyua, Z., M., Kyamanywa S. Erbaugh, M. Miller, S., Dieback disease, devastating passion fruit production in Kenya. A paper submitted for presentation during the 11$^{th}$. Biennial KARI Conference on the 10$^{th}$ -14$^{th}$. November 2008.

Apoo H. 2008. Characterization of passion fruit in Uganda using Random Amplified Polymorphic DNAs (RAPDs). *BSc Special Project Report, Makerere University.*

Asea, G., B. Vivek, G. Bigirwa, P.E. Lipps, and R.C. Pratt. 2009. Validation of consensus QTL associated with resistance to multiple foliar pathogens of maize. *Phytopathology* (Accepted with revision).

Bulali, J. Assessment of the relative importance of tomato (*Lycopersicon esculentum* Mill.) pests in Morogoro, Tanzania. 2008 Sokoine University of Agriculture. Unpublished M.Sc Thesis (Supervisor: Prof. K.P. Sibuga – SUA)

Erbaugh, J.M., J. Donnermeyer, and M. Amujal 2007. Assessing the Impact of Farmer Field School Participation on IPM Adoption in Uganda. Abstracts**,** Journal of International Agricultural and Extension Education, 14 (2), 71.

Erbaugh, J.M., P. Kibwika, and J. Donnermeyer. 2007. Assessing Extension Agent Knowledge and Training Needs to Improve IPM Dissemination in Uganda. Journal of International Agricultural and Extension Education,14 (1), 59-70.

Erbaugh, J. M., Donnermeyer, J., Kyamanywa, S. and Kucel, P. 2008. The Role of Extension in the Assessment Process: Identifying Production Constraints Among Arabica Coffee Producers in Eastern Uganda. Abstracts, Journal of International Agricultural and Extension Education, 15 (2),

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, Vol. 7. pp. 1257-1265.

Karungi, J., Agamire, P., Kovach, J., and Kyamanywa, S. 2008. Cover cropping with cowpea and novel pesticide usage in the management of pests of hot pepper (*Solanum chinense*) in Uganda. *Under review, African Crop Science Journal*

Mtui, H.D., A.P. Maerere, M.D. Kleinhenz, S.A. Miller, M. Erbaugh, and M.A. Bennett. Seed treatment and mulch effects on seedborne bacterial pathogens and yield of tomato (Lycopersicon esculentum mill.) in Tanzania. Program and Abstracts, 2008 Annual Amer. Soc. Hort. Sci. Conference, 21-24 July, 2008, Orlando, FL. HortScience 43(4):1159.

Mtui, H.D., M.A. Bennett, A. P. Maerere, S.A. Miller, M.D. Kleinhenz, K.P. Sibuga and M. W. Mwatawala and M. Erbaugh. 2008. Effect of seed treatment and mulch on seed borne bacterial pathogens and yield of tomato (*Lycopersicon esculentum* Mill.) in Tanzania" (submitted to Elsevier Publishers)

Mtui, Hossea. Seed biology based interventions for enhanced integrated crop management in tomato production by small scale farmers in the Morogoro region, Tanzania. Unpublished Masters' Thesis. The Ohio State University. September, 2007. Advisors: Mark Bennett, Matt Klienhentz, Sally Miller, and A. Maerere

Ochwo-Ssemakula M. 2008. Occurrence, identification and characterization of viruses infecting passion fruit in Uganda. *PhD thesis, Makerere University.*

Ochwo-Ssemakula M, V Aritua, T Sengooba, J J Hakiza, E Adipala, R Edema, P Redinbaugh and S Winter. 2009. The potyvirus infecting cultivated and wild passion fruit in Uganda is a distinctive virus species. *Manuscript in the final stages of review for submission to the Plant Disease Journal*.

Ochwo-Ssemakula M, S Wasike, J J Hakiza, E Adipala and R Edema. Characterization of passion fruit species in Uganda. *Manuscript being written for submission to the HortScience Journal.*

Ochwo-Ssemakula M, E Adipala and R Edema. Screening for virus tolerance in select yellow passion fruit types in Uganda. *Manuscript being written for submission to the African Crop Science Journal.*

Onyango, I. A.; Gitonga, L.M.; Waiganjo, M.M. 2007. Evaluation of management options for tomato pests in Kirinyaga District of Central Province. Presented during the *Second JKUAT Scientific, Technological and Industrialisation Conference*, held at JKUAT 26-27 October, In the book of Abstracts p. 84. Submitted for publication in the *Journal of Agriculture Science and Technology* (JAGST).

Otipa M.J. Distribution, Characterization and Reaction of Passion fruit germplasm to Viruses in Kenya. PhD proposal presented during the annual Post-graduate seminar (1st August, 2008) at Jomo Kenyatta University of Agriculture and Technology. Supervisors; Dr. Elijah Ateka and Dr.Edward Mamati (Department of Horticulture-JKUAT) and Dr Douglas Miano KARI-Biotechnology Centre

Otipa, M. J., Amata, R. L., Waiganjo, M., Ateka, E., Mamati, E., Miano, D., Nyaboga, E., Mwaura, S., Kyamanywa, S.; Erbaugh, M. and Miller, S. Incidences, Severity and Identification of Viral diseases in

Passion fruit production systems in Kenya. A poster presented in the 1st African Biotechnology Congress in Nairobi, Kenya (22nd -26th Sept 2008).

Sibuga, K.P., Bulali, J. E. M., Maerere, M. W. Mwatawala, A. P., Kovach, J, Kyamanywa, S. and Erbaugh, M. Deriving appropriate pest management technologies for smallholder tomato (*Lycopersicon esculentum* Mill.) growers: A case study of Morogoro, Tanzania. (Submitted to Tropical Science)

Waiganjo, M.M.; B.M. Ngari; M.N. Wabule; S.B. Wepukhulu. 2008. Biological Monitoring Of Tomatoes at Mwea-Kirinyaga Kenya. *2007 Annual Report. KARI-Thika*.

Waiganjo, M.M; Onyango, I; M.N. Wabule; B.M. Ngari; S.B. Wepukhulu. 2008. Evaluation of Tomato Pest Management Options at KARI-Thika, Kenya. *2007Annual Report. KARI-Thika*.

Waiganjo M.M., Onyango, I; M.N. Wabule; S.B. Wepukhulu; B.M. Ngari; J. Kovach. Evaluation of Integrated Pest Management Options for Cost Effective Small Holder Tomato Production in Kenya. Submitted for publication in African Journal of Horticultural Science.

Waiganjo, M.M; Wabule, N.M; Kuria, S; Kibaki, J.M; Onyango, I; Wepukhulu, S.B; Muthoka, N.M; D. Taylor. Survey of Knowledge, Practice and Perceptions Relating to Pests and their Management among Small holder Tomato Farmers in Kirinyaga District, Kenya. Paper submitted to the Journal of Agriculture Science and Technology.

Waiganjo, M.M.; Ngari, B; Wabule, M.N; Wepukhulu, S.B; Kovach, J; Taylor, D. Biological Monitoring of Tomato Pests to Ascertain Baseline Information on The Crop Production Constraints in Kirinyaga District, Kenya. Manuscript for Presentation during the 11th KARI Biennial conference and inclusion in a special Edition of the East African Agricultural and Forestry Journal published by KARI.

**Presentations**

Bonabana-Wabbi, J. and Taylor, D. (2008). Health and Environmental Benefits of Reduced Pesticide Use in Uganda: An Experimental Economics Analysis. Presented at annual meeting of American Agricultural Economics Association and the American Council on Consumer Interests in Orlando Florida, July 27-29, 2008.

Erbaugh, J. M., Donnermeyer, J., Kyamanywa, S. and Kucel, P. 2008. The Role of Extension in the Assessment Process: Identifying Production Constraints Among Arabica Coffee Producers in Eastern Uganda. Presented at the 25th Annual conference of AIAEE, March 10-15, San Jose, Costa Rica.

Klienhenz, M. Delivered two lectures to Bsc Horticulture students on (1) Organic Production of vegetables, and (2) Extension Information for farmers

Mtui, H.D., A.P. Maerere, M.D. Kleinhenz, S.A. Miller, M. Erbaugh, and M.A. Bennett. 2008. Effect of seed treatments and mulch on seedborne bacterial pathogens and yield of tomato (*Lycopersicon esculentum* mill.) in Tanzania. Presented by Dr. Matt Klienhenz at the Annual Meeting of the American Society for Horticultural Science, 21 - 24 July, 2008, Rosen Plaza Hotel, Orlando Florida.

Mukasa, S.B., Amayo, R., Karungi, J., and Kyamanywa, S. Prevalence and relative importance of viruses on hot pepper in central Uganda. Paper to be presented at the International IPM symposium, March 24-26, 2009 at the Portland, Oregon.

Pratt, Richard. 1/13/08 – SUA – Seminar title: Linkage of Molecular Markers to Foliar Pathogen Resistance Loci in Maize. M – 21; F – 7; Tot. – 28.

Tusiime, Geoffrey, PCR detection of ***Xanthomonas campestris pv musacearum*** in banana: Implication for mat management to control banana xanthomonus wilt. International Banana Conference, 5-9 October, 2008, Mombasa Kenya.

**Posters**

Amata, R. L., Otipa, M. J., Wabule, M., Kinyua, Z. M., Kyamanyua, S., Erbaugh, J. M. and Miller, .S 2008. Fungal pathogens associated with Passion fruit crop in Kenya. A poster presented in the IPM CRSP Workshop, Manila,
Philippines (May 19-22).

Erbaugh, J.M., S. Kyamanywa, A. Maerere, and M. Wabule. Regional IPM CRSP Program for East Africa: Kenya, Tanzania, and Uganda. Presented at the Annual IPM CRSP meeting in Manila, Philippines, May 2008.

Gesimba, R., D. Struve, L. Rhodes, M. Bennett and M. Erbaugh. The effect of substrate type and Treatment in the Suppression of *Fusarium oxysporium* f. sp. *Passiflorae* under irrigation conditions. Presented at the Annual IPM CRSP meeting in Manila, Philippines, May 2008.

Hosea D. Mtui, Mark A. Bennett, Amon P. Maerere, Sally A. Miller and Matthew D. Kleinhenz: Effect of seed treatments on seedborne bacterial pathogens of tomato (*Lycopersicon esculentum* Mill.) in Tanzania. Presented at the Annual IPM CRSP meeting in Manila, Philippines, May 2008.

Maerere, A. P., Mwajombe K.K., Sibuga, K.P., Kovach, J., and Erbaugh, M. Baseline survey of tomato (*Lycopersicon esculentum* Mill.) production in Mvomero district, Morogoro region in Tanzania

S. Adikini1, F. Beed2, L.Tripathi2, G.Tusiime, M. Mwangi,V. Aritua3, S. Kyamanywa1 and S.B. Miller. "PCR detection of Xanthomonas vasicola pv. musacearum in banana: implication for mat management to control BXW wilt International IPM CRSP Workshop: Advancing Regional and Global IPMCRSP Programs, May 19-21 2008, Manila, Philippines.

Sibuga, K.P., Bulali, J. E. M., Maerere, A. P., Mwatawala, M. W., Kovach, J., Kyamanywa, S., and Erbaugh, M. Efficacy of various management practices on tomato (L*ycopersicon esculentum* Mill) pests: A case study for Morogoro, Tanzania

Waiganjo M. M; Waturu, C.N; Njuguna J.K; Mbugua, G.W; Gitonga, L.W. Banana Production Challenges and Some Research Interventions Undertaken by KARI-Horticultural Program under the USAID-SO7 Project. Poster presented at The International conference on Banana and plantain in Africa: Harnessing International partnerships to increase research impact. Mombasa, Kenya, October 5$^{th}$ -9$^{th}$, 2008.

Waiganjo M.; Wabule M.; Ngari, B.; Kuria, S.; Kyamanywa, S.; Erbough, M.; Kovach, J.; Taylor, D and Maxwell, D. Smallholder Tomato Production Constraints In Kirinyaga District, Kenya and Some Promising Interventions Identified Through The IPM- CRSP Participatory Research a poster presented in the IPM CRSP Workshop, Manila, Philippines (May 19-22).

**Three extension booklets on tomato IPM production were developed in Tanzania:**
1) Management of Weeds in Tomato Farms in Morogoro district (In ki-Swahili). K.P. Sibuga, A.P. Maerere, M.W. Mwatawala and H.D. Mtui.;
2) Management of Diseases in Tomato Farms in Morogoro district (In ki-Swahili); A.P. Maerere, H.D. Mtui, K.P. Sibuga and M.W. Mwatawala;
3) Management of Insects in Tomato Farms in Morogoro district (In ki-Swahili).M.W. Mwatawala, A.P. Maerere, K.P. Sibuga and. H.D. Mtui

In Tanzania, TACRI produced:

- a poster (1000 copies) and a fact sheet (4000 copies) on safe handling of pesticides.
- Coffee Pest identification, severity assessment and management
- Use of botanical extracts as biopesticides on coffee pests
- Integrated pest management strategies for coffee smallholder farmer.

## Regional Integrated Pest Management Research and Education for South Asia

**Publications and Presentations**

Alam, S.N., M. A. Sarker, A. K. M. Z. Rahman, M. I. Islam, M. Yousuf Mian, M. Nasiruddin, Edwin G. Rajotte, and A. N. M. R. Karim. 2008. Integrated management of fruit fly and borer complex in bitter gourd crop. A poster presented at the workshop on 'Advancing Regional and Global IPM CRSP Programs' held at the Manila Hotel, Manila, Philippines, May 18-21, 2008.

Rakshit, Atanu, Integrated Pest Management in Bangladesh: An Impact Assessment of Pheromone Adoption for Cucurbit Crops, M.S. Thesis, Virginia Tech, Blacksburg, VA.

Ricker-Gilbert, Jacob, George W. Norton, Jeffery Alawang, Monayem Miah, and Gershon Feder. 2008. Cost-effectiveness of alternative integrated pest management extension methods:An example from Bangladesh. Rev. Agril. Econ. 30(2):252-269.

Uddin, M. Nazim, M. Mozammal Hoque, S. M. Monowar Hossain, S. N. Alam, A. K. M. Salim Reza Mollik, A. K. M. Khorsheduzzaman, Siddique Alam, Mahbubur Rahman, A. N. M. R. Karim, E. G. Rajotte, and G. C. Luther. 2007. IPM approach for controlling two lepidopteran pests of cabbage in Bangladesh. Bangladesh J. Entomol. 17(1): 19-29.

Zaman, Faruque. 2008. A Comparison of Univoltine and Multivoltine European Corn Borer (ostrinia numbilalis Hubner): Life History Characters, Bt Toxin Susceptibility, Parsitoid Impact and Population Pattern**.** Ph.D. Dissertation. Penn State University, University Park, PA.

## Ecologically-based Participatory IPM for Southeast Asia

Baltazar A.M. and J. L. Opena. 2007. Managing weeds in eggplant with less inputs. Presented at the $38^{th}$ conference of the Pest Management Council of the Philippines. Tagbilaran City, Bohol. May 20-23, 2007.

Baltazar A.M. and J.L. Opena. 2008. Agroecological approaches to managing weeds in eggplant using stale-seedbed technique. Oral presentation at the $5^{th}$ International Weed Science Congress, Vancouver, Canada. June 23-27, 2008.

Opena, J.L., A.M., Baltazar, C.B. Adalla, and N. L. Opina. 2008. Agroecological approaches to managing weeds in eggplant using the stale-seedbed technique.
Presented at the IPM CRSP meeting, Manila, Philippines. May 19-21, 2008. (poster)

## Ecologically-Based Participatory and Collaborative IPM Research and Capacity Building Program in Central Asia

Aitmatov, M. and N. Saidov. 2008. Translation of "Sunn Pest Management" brochure from English into Tajik and Kyrgyz. 100 copies published. Distributed to farmers in Tajikistan and Kyrgyzstan.

Aitmatov, M., G. Bird, W. Pett and D. Baributsa. 2008. Development and Dissemination of IPM knowledge through Outreach and University Education Programs in Central Asia. *In* K. Maredia and D. Baributsa (eds). Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Aitmatov, M., B. Masaidov and N. Saidov. 2008. Brochure on “Botanical pesticides to control vegetables and fruit pests” (in Kyrgyz and Russian). 46 pages. 100 copies published.

Landis, D., M. Gardiner, A. Fiedler, A. Costamagna and N. Saidov. 2008. Landscape Ecology and Management of Natural Enemies in IPM Systems. *In* K. Maredia and D. Baributsa (eds). Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Maredia, K. and D. Baributsa (eds). 2008. Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Maredia, K. and D. Baributsa. 2008. Ecologically-based Participatory and Collaborative Research and Capacity Building in Integrated Pest Management in Central Asia Region. In K. Maredia and D. Baributsa (eds). Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Mavlyanova, R., M. Aitmatov, N. Saidov and M. Shodmonov. 2008. Field guide “Weeds in vegetable crops" (in Russian). 36 p. 170 copies published.

Murat, A. G. Bird and G. Kaseeva. 2008. Strengthening Student Research Capacity Through Student Field School. Article published in the Bulletin of the Kyrgyz Agrarian University. 6p. March 2008.

Saidov, N., D. Landis and M. Bohssini. 2008. A History of Habitat Management in the Former USSR and the Commonwealth of Independent States and Current Research in Central Asia. 2007. *In* K. Maredia and D. Baributsa (eds). Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Saidov, A., N. Saidov, V. Nazirov. 2008. Pest Management Practices and Strategies in Tajikistan. *In* K. Maredia and D. Baributsa (eds). Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Saidov, N. and D. Landis. 2008. Evaluation of Flowering Plants to Attract Natural Enemies in Tajikistan (Russian). Bulletin of the Academy of Science of Tajikistan. *In press.*

Saidov, N., A. Jalilov, P. Geraedts and F. Zalom. 2008. Pocket book "Tomato pest and disease" (in Tajik). Published 500 copies through funding from the National Agricultural Advisory System (SENAS) in Tajikistan.

Saidov, N. September 2008. Landscape ecology and biological pest management. Agro-Advice, Quarterly electronic newsletter. Written for wider dissemination targeting various stakeholders such as authorities, local farmers, and NGO.

Tashpulatova, B. and F. Zalom. 2008. Enhancing the Efficiency and Product Lines of Biolaboratories in Central Asia. *In* K. Maredia and D. Baributsa (eds). Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Tashpulatova, B. 2008. Integrated Pest Management in Uzbekistan. *In* K. Maredia and D. Baributsa (eds). *In* Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Tashpulatova, B. 2008. Integrated Pest Management in Uzbekistan. *In* K. Maredia and D. Baributsa (eds). *In* Integrated Pest Management in Central Asia. Proceedings of the Central Asia Regional IPM Forum, Dushanbe, Tajikistan, May 2007.

Tashpulatova, B., F. Zalom and J. T. Tumanov. 2008. Effect of *Amblyseius mckenziei* (Acarina:Phytoseiidae) on *Thrips tabaci* (Thysanoptera: Thripidae) on onion crop in Uzbekistan.

Proceedings of the 1st International e-Conference on Agricultural BioSciences. Abstract ID: IeCAB08-145, http://www.e-conference.elewa.org/agriculture. June 2 - 16, 2008

Tashpulatova, B., F. Zalom and J. T. Tumanov. 2008. Usage of *Amblyseius cucumeris* (acari:phytoseiidae) to control of greenhouse whitefly *Trialeurodes vaporariorum* (westwood) (homoptera: aleyrodidae) on tomato plant. International conference "Actual directions in development of scientific research on potato and vegetable" Kaskelen (Kazakhztan), June 9-11, 2008, P. 50-53.

Tashpulatova, B., F. Zalom and J. T. Tumanov. 2008. Biological control of *Thrips tabaci* (Thysanoptera: Thripidae) using *Ambliseius mckenziei* (Acarina:Phytoseiidae) on onion crop in Kyrgyzstan and Uzbekistan. Conference devoted to 50 years anniversary of Institute of Plant Protection and Quarantine – Kazakhstan, 6-8 November, 2008 (in press).

**Abstracts:**

Nurali S., H. Saidov and D. Landis. 2008. The Evaluation of Flowering Plants to Attract Natural Enemies in Tajikistan. The thesis sent to Scientific Conference dedicated to the 50th Anniversary of Kazakh Institute of plant protection and quarantine which will be held on November 6-8, 2008.

Saidov, N. and D. Landis. 2008. Landscape Ecology and Biodiversity to Enhance Biodiversity and Biological Pest Management. Abstract accepted for oral presentation to Ninth International Conference on Dry Land Development: Sustainable Development in Dry Land-Meeting the Challenge of Global Climate Change, 7-10 November 2008, Alexandria, Egypt.

Saidov, A., N. Saidov, B. Nakhshiniev. 2008. Some aspects of climate change on fauna of Tajikistan. Abstract accepted for oral presentation to Ninth International Conference on Dry Land Development: Sustainable Development in Dry Land-Meeting the Challenge of Global Climate Change, 7-10 November 2008, Alexandria, Egypt.

**Presentations:**

Aitmatov, M. and G. Bird. 2008. IPM Farmer Field School Extension and Outreach Programs in Central Asia. Presented during the IPM CRSP Workshop "Advancing Regional and Global IPM CRSP Programs"; May 19-21, 2008, Manila, Philippines.

Maredia, K. and D. Baributsa. May 2008: Ecologically-based Participatory and Collaborative Research and Capacity Building in IPM in Central Asia Region, presentation during the IPM CRSP workshop, Manila, Philippines.

Saidov N. and D. Landis. 2008. Landscape Ecology and Biodiversity to Enhance Biodiversity and Biological Pest Management. Presented during the IPM CRSP Workshop "Advancing Regional and Global IPM CRSP Programs"; May 19-21, 2008, Manila, Philippines.

Tashpulatova and F. Zalom. Enhancing Efficiency and Expanding Product Lines of Central Asia Biolaboratories: Laboratory and Field Studies of the Predaceous Mites Amblyseius cucumeris and Amblyseius mckenziei, IPM CRSP Workshop on "Advancing Regional and Global IPM CRSP Programs"; May 19-21, 2008, Manila, Philippines.

Two power point presentations by Dr. Nurali Saidov at the "Organic Week workshop in Tajikistan" organized by the Oxfam GB in Tajikistan from 17-20 October 2007.

- Introduction to Organic Agriculture
- Pest management in organic crops.

## Integrated Pest Management of Specialty Crops in Eastern Europe

***Ukraine - L'viv***

Three publications promoting IPM practices in fruit crops were published:

Шестопал, Г., і Д. Файфер. 2008. Яблуня – Комерційна Культура в Україна. [Shestopal, G., and D. Pfeiffer. 2008. Apple - A Commercial Crop for Ukraine.] Tsov "Triada-Plus". L'viv, Ukraine. 256 p. 20 pls.

Гадзало, Я. М., З. А. Шестопал, А. Т. Коваль, і Г. С. Шестопал. 2007. Довідник Садівника. [Gadzalo, Y., Z. A. [Shestopal, Z. A., A. T. Koval and G. S. Shestopal. A Manual for Orchard and Small Fruit Producers.] Svit Publishing, L'viv, Ukraine. 280 p.

Gadzalo, Y., G. S. Shestopal and Y. S. Shestopal. Intensive Technologies for Small Fruit Production. Svit Publishing, L'viv, Ukraine. 272 p.

***US:***

Pfeiffer, D. G. 2008. IPM CRSP and challenges facing apple production. L'viv Oblast Apple Growers Symposium. Mostsy'ka. 6 Aug.

Pfeiffer, D. G. and S. A. Miller. 2008. Status of IPM CRSP research in Eastern Europe in Year 3. Manila, Philippines. May 18.

Pfeiffer, D. G. 2008. Scholar Site "IPM CRSP Eastern Europe". A password-protected, on-line site for communication and file sharing among US and host country participants. (http://scholar.vt.edu)

Pfeiffer, D. G. 2008. Eastern European Regional Program for Integrated Pest Management Collaborative Research Support Program. Public access web site.
(http://www.virginiafruit.ento.vt.edu/Albania/EasternEuropeIndex.html)

Albania (http://www.virginiafruit.ento.vt.edu/Albania/AlbaniaIndex.html)
Moldova (http://www.virginiafruit.ento.vt.edu/Albania/MoldovaIndex.html)
Ukraine (http://www.virginiafruit.ento.vt.edu/Albania/UkraineIndex.html)

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

**Publications**

*(i) Peer reviewed publications*
Dhileepan, K. and Strathie, L. 2008. *Parthenium hysterophorus* In: *Weed Biological Control with Arthropods in the Tropics: Towards Sustainability.* Muniappan, R., Reddy, G.V.P., Raman, A. and Gandhi, V.P. (eds). Cambridge University Press. *In press.*

Ntushelo K. and Wood AR. 2008. Supplementary host-specificity testing of *Puccinia melampodii*, a biocontrol agent of *Parthenium hysterophorus*. In: *Proceedings of the XII International Symposium on Biological Control of Weeds*, Montpellier, France, April 2007. Julien, M.H., Sforza, R., Bon, M.C., Evans, H.C., Hatcher, P.E., Hinz, H.L. & Rector, B.G. (eds), CAB International Wallingford, UK. In press.

Strathie, L.W., McConnachie, A.J. and Negeri, M. 2008. A cooperative approach to biological control of *Parthenium hysterophorus* (Asteraceae) in Africa. In: *Proceedings of the XII International Symposium on*

*Biological Control of Weeds*, Montpellier, France, April 2007. Julien, M.H., Sforza, R., Bon, M.C., Evans, H.C., Hatcher, P.E., Hinz, H.L. & Rector, B.G. (eds), CAB International Wallingford, UK. In press.

*(ii) Non-peer reviewed publications*

Strathie, L. and McConnachie, A. 2007. Managing the impact of parthenium invasions in Africa. *Biocontrol News and Information 28(3): 54N-55N.*

Taylor, J. M. 2007. Seed bank studies of the alien invasive weed, *Parthenium hysterophorus*, in the eastern areas of South Africa. University of KwaZulu-Natal, BSc Honours Ecological Sciences (Rangeland & Wildlife Conservation).

King, H. 2008. Thermal physiology and predictive modeling of *Zygogramma bicolorata*: a potential biological control agent for *Parthenium hysterophorus* in South Africa. University of KwaZulu-Natal. Unpublished MSc thesis.

**Presentations**

McConnachie, A. Here, there and everywhere! Parthenium distribution surveys in eastern and southern Africa. IPM CRSP Parthenium Project Partners Workshop, Addis Ababa, Ethiopia, October 12, 2007.

McConnachie, A., Strathie, L. Ntushelo, K. and Goodall, J. Control of *Parthenium hysterophorus* (Asteraceae) in conservation areas in South Africa. Southern African Wildlife Management Association Symposium, September 18-21 2007, Didima Camp - uKhahlamba-Drakensberg Park. (Approximately 60 delegates, ~70% men, ~30% women)

McConnachie, A. Biological control of *Campuloclinium macrocephalum.* Pongola/Nongoma landowners' day 19 March 2008. (Approximately 30 participants, ~ 28 men + 2 women)

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## APPENDICES

# Appendix A—List of Acronyms

| | |
|---|---|
| ACDI/VOCA | Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance |
| ADESJO | Association for the Development of San Jose de Ocoa |
| 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 |
| ARC-PPRI | Agriculture Research Council- Plant Protection Research Institute |
| 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 |
| BARC | Bangladesh Agricultural Research Council |
| BARI | Bangladesh Agricultural Research Institute |
| BBWV | Broad Bean Wilt Virus |
| BER | Blossom End Rot |
| BLM | Black Leaf Mold |
| BPI | Bureau of Plant Industry |
| BSU | Benguet State University |
| BSMRAU | Bangabandhu Sheikh Mujibur Rahman Agricultural University |
| BW | Bacterial Wilt |
| CAB I | Commonwealth Agricultural Bureau International |
| CEDEH | Experimental and Demonstration Center for Horticulture |
| CERES | Centre de Recherche en Ecotoxicologie pour le Sahel |
| CGIAR | Consortium for International Agricultural Research |
| ChiVMV | Chilli Veinal Mottle Virus |
| CIAT | International Center for Tropical Agriculture |
| CILSS | Comite Inter-Estate pour la Lutte contre la Sécheresse au Sahel |
| CIMMYT | International Maize and Wheat Improvement Center |
| CIMS | Clinic Information Management System |
| CIP | International Potato Center |
| CLB | Cereal Leaf Beetle |
| CLCuGB | Cotton Leaf Curl Gezira Betasatellite |
| CLCuGV | Cotton Leaf Curl Gezira Virus |
| CLIMEX | Predictive model for species distribution according to climate |
| 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 |
| CSIRO | Australia's Commonwealth Scientific and Industrial Research Organisation |
| CYSDV | Cucurbit Yellow Stunting Disorder Virus |
| CU | Coordinating Unit |
| DA | Department of Agriculture |
| DAC | Direct Antigen Coating |
| DAC-ELISA | Direct Antigen Coating-Enzyme-Linked Immunosorbent Assay |

| | |
|---|---|
| DAE | Department of Agricultural Extension |
| DAI | Development Alternatives Inc. |
| DBM | Diamond Back Moth |
| DDIS | Distance Diagnostic and Identification System |
| DPPI | Degradable Polymer Products Incorporated |
| DPV | Direction de la Protection des Vegetau, Sénégal |
| DTI | Department of Trade and Industry |
| EA | East Africa |
| EFSB | Eggplant Fruit and Shoot Borer |
| EI | Ecoclimatic Index |
| EIAR | Ethiopian Institute for Agricultural Research |
| ELISA | Enzyme-Linked Immunosorbent Assays |
| ERP | External Review Panel |
| ETQCL | Environmental Toxicology and Quality Control Laboratory, Mali |
| FAO | Food and Agricultural Organization |
| FASAGUA | Federación de Asociaciones Agrícolas de Guatemala |
| FFS | Farmers Field Schools |
| FGD | Focus Group Discussion |
| FHIA | Honduran Foundation for Agricultural Research |
| FIELD | Farmers Initiatives for Ecological Literacy and Democracy |
| FoSHoL | Food Security for Sustainable Household Livelihoods |
| FPA | Fertilizer and Pesticide Authority |
| FPE | Farmer participatory experiments |
| FSB | Fruit and Shoot Borer |
| GIS | Geographical Information System |
| GMED | Growth and Micro Enterprize Development |
| GPS | Global Positioning System |
| GTZ | German Technical Cooperation |
| HoLCrV | Hollyhock Leaf Crumple Virus |
| 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 |
| IDIAF | Campo Experimental del Instituto Dominicano de Investigaciones Agropecuarias y Forestales |
| 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 |

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| JAEC | Japan Agricultural Exchange Council |
| KARI | Kenya Agricultural Research Institute |
| LAC | Latin America and Caribbean |
| MCC | Mennonite Central Committee |
| MOA | Memorandum of Agreement |
| MOC | Mustard Oil-cake |
| MoAFCP | Directory of Science and Extension service, Albania |
| MSG | Mashed Sweet Gourd |
| MU/FA | Makerere University Faculty of Agriculture |
| NARC | National Agricultural Research Center |
| NSKE | Neem seed kernel extract |
| NGOs | Non-Governmental Organizations |
| OHVN | L'Office de alla Haute Vallée du Niger, Mali |
| OLCD | Okra Leaf Curl Disease |
| OMAG | Office of the Municipal Agriculturist |
| OPAG | Office of the Provincial Agriculturist |
| OTOP | One Town, One Product, A promotion |
| OYCrV | Okra Yellow Crinkle Virus |
| PAN | Pesticide Action Network |
| PBNV | Peanut Bud Necrosis Virus |
| PCFV | Peanut Chlorotic Fanleaf Virus |
| PCI | Pest Control India |
| PCR | Polymerase Chain Reaction |
| PDA | Potato Dextros Agar |
| PH | Protein Hydrolysate |
| PIS | Perceived Impact Score |
| PPP | Participatory Planning Process |
| PPRC | Plant Protection Research Centre |
| PSE | Pesticide Safety Education |
| PTM | Potato Tuber Moth |
| PYSV | Peanut Yellow Spot Virus |
| PYVMV | Pepper Yellow Vein Mali Virus |
| PRSV | Papaya Ring Spot Virus |
| QDNR&M | Queensland Department of Natural Resources and Mines |
| QDS | Quarter Degree Square |
| QPCR | Quantitative Polymerase Chain Reaction |
| QuEChERS | Quick, Easy, Cheap, Effective, Rugged, and Safe method of pesticide residue testing |
| RADHORT | Réseau Africain de Development de l'Horticulture, Sénégal |
| RC | Regional Coordinator |
| RCBD | Randomized Complete Block Design |
| RKN | Root-knot Nematode |
| RP/EA | Regional Program for East Africa |
| RTC | Regional Technical Committee |
| RT-PCR | Reverse Transcription-polymerase Chain Reaction |
| SAGIC | Support for Accelerated Growth and Increased Competitiveness |
| SAPIA | South African Plant Invaders Atlas |
| SBAL | Safe Agricluture Bangladesh Limilted |
| SCR | Scottish Research Institute |
| SeNPV | *Spodoptera exigua* Nuclear Polyhedrosis Virus |
| SEPAS | Société d'exploitation des produits agricoles du Sénégal |
| SPCL | Sustainable Perennial Crop Lab |
| SUA | Sokoine University of Agriculture, Tanzania |
| TACRI | Tanzania Coffee Research Institute |
| TAS | Triple Antibody Sandwich |
| TBIA | Tissue Blotting-Immunobinding Assay |

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| TERI | The Energy Research Institute |
| TEV | Tobacco Etch Virus |
| TLCV | Tomato Leaf Curl Virus |
| TLCMV | Tomato Leaf Curl Mali Virus |
| TMV | Tobacco Mosaic Virus |
| TNAU | Tamil Nadu Agricultural University |
| ToANV | Tomato Apex Necrosis Virus |
| TSV | Tobacco Streak Virus |
| TSWV | Tomato Spotted Wilt Virus |
| TYFRV | Tomato Yellow Fruit Ring Virus |
| TYLCV | Tomato Yellow Leaf Curl Virus |
| TYLCMV | Tomato Yellow Leaf Curl Mali Virus |
| UC-D | University of California, Davis |
| UPLB | University of the Philippines at Los Banos |
| USAID | United States Agency for International Development |
| USDA/ APHIS | US Department of Agriculture, Animal and Plant Health Inspection Service |
| USDA/ARS | US Department of Agriculture/ Agricultural Research Service |
| VAM | Vesicular Arbuscular Mycorrhiza |
| V-GET | Virtual Geo-Reference |
| WACIP | West Africa Cotton Improvement Porgram |
| WBNV | Watermelon Bud Necrosis Virus |
| WMV2 | Watermelon Virus-2 |
| WSMoV | Watermelon Silver Mottle Virus |
| WSU | Washington State University |
| WTV | Whitefly-transmitted Geminiviruses |
| YVMV | Yellow Vein Modaic Virus |

# 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
The Ohio State University
Oregon State University
Pennsylvania State University
Purdue 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 Developpment de l'Horticulture, Senegal
Samarkand Agricultural Institute, Uzbekistan
Sam Ratulangi University in North 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 Hyderabad, India
University of Queensland, Australia
University of Southern Mindanao, Philippines
University of the West Indies, Trinidad
World Cocoa Foundation
World Conservation Union, Kenya
Zamorano 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
The Energy and Resources Institute
Practical Action Bangladesh
CARE Bangladesh
Mennonite Central Committee
Action Aid Bangladesh
FIELD Indonesia
ACDI VDCA