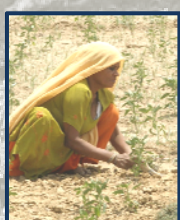
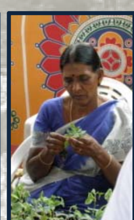
Integrated Pest Management
Collaborative Research Support Program

Annual Report





Phase III – Year Five: 2008-2009

USAID Cooperative Agreement No: EPP-A-00-0400016-00

USAID FROM THE AMERICAN PEOPLE

VirginiaTech Invent the Future

Management Entity for IPM CRSP: Office of International Research, Education, & Development (OIRED)
Virginia Tech, 526 Prices Fork Road, Blacksburg, VA 24060, www.oired.vt.edu/ipmcrsp/

Integrated Pest Management
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FY 2009
Annual Report

October 1, 2008 – September 30, 2009

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USAID Cooperative Agreement No: EPP-A-00-0400016-00

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EXECUTIVE SUMMARY

Losses due to insects, diseases, weeds, nematodes, and other agricultural pests are a major constraint to improved agricultural productivity in developing countries. Integrated Pest Management (IPM) has gained increased attention in recent years as a means of reducing losses due to pests, minimizing reliance on chemical pest control, and, therefore, fostering the long-term sustainability of agricultural systems. The Integrated Pest Management Collaborative Research Support Program (IPM CRSP) is an initiative of USAID. It is a collaborative partnership among U.S. and host country institutions with an emphasis on research, education, training, and information exchange. Virginia Tech has been implementing the IPM CRSP for the past 16 years with continuous support from USAID. The objective of this report is to present the progress and notable achievements by the seven regional and six global theme projects of the IPM CRSP during FY 2009.

Regional Programs:

Latin America and the Caribbean (LAC)
Crops for Broad-based Growth and Perennial Production for Fragile Ecosystems

In Ecuador, 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 *Moniliophthora perniciosa.* The resistant SCA clones showed lower incidence values than the others. In 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. One hundred fifty F3 segregating plants from five crosses between *Solanum quitoense* (naranjilla) with *S. hyporhodium*, *S. vestissimum* and *S. felinum* received from the Indiana State University were evaluated for resistance to *Fusarium oxysporum* and *Phytophthora infestans*.

In Honduras, solarisation and anti-insect screen houses were introduced for production of disease and insect free seedlings. Hot water treatment of strawberry planting materials proved to be effective in controlling the mites and the use of thermal mesh bags for control of papaya fruit fly *Toxotrypana curvicauda* reduced the infestation by 80%.

A preliminary evaluation indicated that the eggplant fruit borer (*Neoleucinodes elegantalis)* identified in South America may be a different species form the one that was identified in Central America. The pheromone used for monitoring the eggplant fruit borer attracted the South American population, but did not attract the Central American population. Furthermore, the Central America eggplant fruit borer does not feed on tomatoes but the South American population does.

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

Screening tomato varieties for resistance to bacterial wilt in Kenya indicated that the variety MT56 was resistant but the fruits had a very poor shelf life and a round shape which made them unpopular for the local market. Therefore, it was suggested that MT56 be used as a rootstock in grafting trials. Tomato seedlings raised in screen houses were protected from the infection of early and late blights and infestation of whiteflies and lygus bugs.

In Tanzania, mulching with dried grass or rice straw conserved moisture, reduced weeds in the field, increased the vigor of the plants and reduced the incidence of blossom end rot in tomatoes. The most dominant weeds were blackjack (*Bidens pilosa*), wondering jew (*Commelina benghalensis*), mexican fireplant (*Euphorbia heretophylla*), and false amaranth (*Digera muricata).* Spiderplant (*Cleome gynandra*) and Tanzanian sunhemp (*Crotalaria ochroleuca*) as repellant crops and marigold (*Tagetes sp*.) as a trap crop for thrips in tomato fields were tested. The orange flower marigold type attracted more thrips. *Helicoverpa armigera* moths were captured in pheromone traps received from India, indicating the similarity of the populations in south Asia and East Africa. The melon aphid (*Aphis gossypii)* has been confirmed as the vector of passion fruit virus disease in Uganda. Soil application of *Trichoderma harzianum* and *T. asperellum* were found to be effective in controlling soil borne fungal diseases of passion fruit. *Passiflora edulis* has been identified as resistant to Fusarium wilt. A PCR technique has been developed to monitor progressive movement of *Xanthomonas campestris* pv. *musacearum* in apparently healthy banana suckers. White coffee stem borer, antestia bug and coffee berry borer were the serious pests of coffee in Tanzania. Occurrence of six species of thrips: *Frankliniella occidentalis, Thrips tabaci, Frankliniella schultzei, Scirtothrips dorsalis, Ceratothrips ericae*, and *Thrips palmi* in tomato and pepper fields in Uganda have been confirmed. *Tomato spotted wilt virus* (TSWV) and *Impatiens necrotic spot virus* (INSV) have also been identified in Uganda.

West Africa
Regional Consortium of Integrated Pest Management Excellence

Whitefly densities on both crops and weeds are lower at the Mali sites compared with any of the cropping regions in Senegal. Whitefly activity appears to be concentrated from December to March in Mali and whitefly abundance is not only higher than in Mali but is also relatively constant throughout most of the year in Senegal. *Bemisia tabaci* is a species complex consisting of 13 or more biotypes and two extant species, *B. tabaci* and *B. argentifolii*. The biotypes are known to vary in their biology, dynamics, host ranges, and their ability for virus transmission.

South Asia
Regional Integrated Pest Management Research and Education

In Bangladesh, 13 major research activities and five large technology transfer programs for farmers were completed. The technology transfer was conducted by extension agents, target farmers, and NGO technicians trained by IPM CRSP scientists. 630 agents and several thousand farmers were trained. Four scientists (all male) were trained at the graduate level in Bangladesh, India, and the United States. In Nepal, three technologies were imported from Bangladesh, namely mashed sweet gourd (MSG) traps, soap-water, and grafting from BARI. Among them, the soap water traps, used against fruit flies on cucurbits, was highly successful in many project districts and is expected to replace chemical pesticide traps. NARC scientists were successful in grafting desirable high yielding varieties of tomato and eggplant as a scion to a native and wild plant from Solanacae family expressing tolerance to root knot nematode, and bacterial and fusarium wilt diseases. The technology has extended to Surkhet, Banke, Rupendehi, Kabhre, Lalitpur and Kaski districts. Some nursery growers from Kaski and Lalitpur districts have started demonstrating how to graft tomato plants. In India, two primary collaborating institutions are Tamil Nadu Agricultural University (TNAU) and The Energy and Resources Institute (TERI). At TNAU, there are three major activities: conducting IPM trials with eggplant and okra, organizing training programs on grafting technology in tomato, and documenting insecticide resistance and population diversity in eggplant fruit and shoot borer and whitefly. At TERI, demonstrations on IPM practices were held on vegetable farms in five villages in Utter Pradesh, five villages in Andhra Pradesh, and four villages in Karnataka. Crops included eggplant, okra, tomato, and cucurbits.

Southeast Asia
Ecology-Based Participatory Integrated Pest Management

A new virus disease of yardlong bean has been identified. Pheromone-baited traps (cosmolure) used for monitoring banana corm weevil (*Cosmopolites sordidus)* indicated that more weevils were caught on less-managed fields than in well-managed fields. The capture of *Helicoverpa armigera* in the pheromone traps received from India proved that the populations in Indonesia and India are similar. Papaya mealybug, *Paracoccus marginatus*, a new accidental introduction to Indonesia, has been found to have established in Java, Bali, and Sulawesi. An IPM package for broccoli was developed, consisting of a blend of *Trichoderma* with bokashi, dipping of seedling in *Bacillus subtilis* and *Pseudomonas fluorescens,* lower rate of synthetic fertilizers, hand-picking and botanical insecticide for the control of lepidopteran pests. IPM practicing farmers obtained a profit of 2 to 4 times over non-IPM practitioners. Six farmers' laboratories have been established for the production and use of *Trichoderma*, *Pseudomonas fluorescens* and *Bacillus subtilis* in Indonesia. Extracts of yambean and turmeric mixed with *Spodoptera litua* NPV for UV protection increased the efficacy 10 and 8 times the control respectively. Tomatoes were infested by the leafminer *Liriomyza sativae* in North Sulawesi. The parasitoids emerged from larvae of *L. sativae* were *Hemiptarsenus varicornis, Gronotoma micromorpha, Neochrysocharis* sp. and *Opius* sp. The most dominant parasitoid was *H. varicornis*.

The IPM package for eggplant in the Philippines consists of treating the soil with VAM and *Trichoderma*; grafting Casino cultivar on EG-203, a bacterial wilt-resistant cultivar developed by AVRDC for resistance to bacterial wilt; release of 20,000 earwigs/ha (*Euborelia annulata*); six releases of 50 Trico cards per release; and adopting stale-seedbed technique for weed control. Eggplant yield was 1.5 times higher in the IPM plots over the non-IPM plots. Several sessions were conducted to train the farmers in the production of VAM and *Trichoderma.* Leaf miner, *Liriomyza* sp. is a serious problem in string beans in the Philippines. Parasitoids found attacking leafminer were *Diglypus isaea*, *Asecodes delucchi*, *Hemiptarsenus variconis*, and *Neochrychollis okazakii*. Whiteflies were causing up to 82% yield loss in tomatoes in the Philippines. Yellow polyethylene mulching reduced the incidence of whiteflies.

Central Asia
Ecologically-based Participatory and Collaborative Integrated Pest Management Research and Capacity Building Program

Ten species of nectar plants namely, dill, coriander, marigold, interrupta, sweet basil, balsam, pyrethrum, fennleaf yarrow, horse mint, and sweet fennel were introduced into existing farming systems in various agro-ecological zones of Tajikistan and Kyrgyzstan in collaboration with farmers and NGOs. Establishment of nectar plants in the crop fields increased the natural enemies of the families Coccinellidae, Nabidae, Anthocoridae, Syrphidae, Tachinidae, Chrysopidae, Vespidae, Sphecidae, Ichneumonidae, Braconidae, and Chalcidoidea. Release of 20 to 25 predatory mites, *Amblyseius mckenziei* for control of the phytophagous mite, *Tetranychus urticae* at a density of 150-250 individuals per plant in cotton fields resulted in decline of pest numbers in about 10 days. The development of the predatory mite *Amblyseis cucumeris* on *T. urticae* and pollen grains was studied. The predatory bug *Macrolophus nubilis,* and thrips predator *A. cucumeris* were found to feed on the whitefly *Trialeurodes vaporariorum.* It was also parasitized by *Encarsia Formosa. Helicoverpa armigera* pheromone traps imported from India and set up in tomato fields in Uzbekistan, Tajikistan and Kyrgyzstan attracted moths indicating that *H. armigera* populations in Central Asia and South Asia are the same. Pheromone traps set up for the western flower thrips, *Frankliniella occidentalis* did not attract any thrips indicating that this thrips is absent in Central Asia. Several wheat lines were screened for resistance to cereal leaf beetle (*Oulema melanopus*). The wheat lines: Erythrospermum 13\ Erythrospermum 165; Ferrugineum 205\ Frunsenskaya 60 (2 lines); Lutescencs 42\ Odesskaya krasnokolosaya; Intensivnaya\Norin 38\\ Krasnovodopadsk; Lutescencs 6300\ Ilichevka\Selinnaya 21; Frunsenskaya 60; Krasnovodopadskaya 210\ Peressvet (2 lines); Erythrospermum 1185\1; Lutescencs 1207\1 (3 lines); Erythrospermum 760\1 showed high levels of resistance to cereal leaf beetle.

Eastern Europe
Integrated Pest Management of Specialty Crops in Eastern Europe

In Albania, the treatments with bionematicides Softguard (chitosan oligosaccharin) and Nemafung (K_2O plus plant extract) have given effective control of root knot nematode

(*Meloidogyne incognita*) on pepper plants in plastic greenhouses. Good results in control of twospotted spider mite were obtained by using bio-rationale products, Naturalis (*Beauveria bassiana* 7.2%) and Neemazal (Azadirachtin 10.0g/l). Naturalis and Neemazal treatments consistently had populations that were significantly lower than the control. The level of mortality was 79 and 82%, Naturalis and Neemazal respectively. Keniatox Verde (Natural Pyrethrum 40g/l) was found to be effective in control of the whitefly, *Trialeurodes vaporariorum* on tomatoes. Rotating Serenade (*Bacillus subtilis*), with Daconil (chlorothalonil) helped to reduce resistance development by the botrytis fungus in green house tomato plants. In Moldova, the insecticidal activities of the rape seed oil derivatives were investigated for the control of greenhouse whitefly (*Trialeurodes vaporariorum*), twospotted spider mite (*Tetranychus urticae*) and aphid (*Aphis gossypii*). The insecticidal and miticidal microemulsion does not cause phytotoxicity but has satisfactory effects even when used in a lower concentration. A new liquid copper formulation (Funecol 0.2-0.3%) was effective in reducing the incidence of *Alternaria* in tomato fields. *A* mixture of *Reynoutria* extract and microemulsion based on a rape seed oil derivative controlled powdery mildew in cucumbers. Yellow sticky traps used together with microemulsion based on rape seed oil derivatives treatments controlled the whitefly. In Ukraine, application of Flavobacterin and Agrofil to the soil instead of mineral fertilizers increased the yield in cucumbers. Of the cover crops, timothy, white clover and lawn grass used as cover crops in apple orchards, white clover cover gave better results. Foxtail (*Setaria glauca*) was the most dominant weed in the apple orchard.

Global Theme Programs:

Management of *Parthenium hysterophorus*

Occurrence of parthenium in Uganda has been confirmed. A 46 sq m quarantine facility for host specificity testing imported natural enemies of parthenium has been established at Ambo, Ethiopia. A starter colony of 300 larvae and 531 adult beetles (*Zygogramma biocolorata*) were introduced from ARC-PPRI, South Africa to Ethiopia for bio-control and host-specificity studies. The results of host range testing under the no-choice condition showed that *Z. bicolorata* is safe for crop and non-crop plants closely related to parthenium. After reviewing the data, the Ethiopian Ministry of Agriculture and Rural Development granted a permit to release *Z. bicolorata*. USAID permit for field release is yet to be obtained. Five hundred adults of another natural enemy, a stem boring weevil, (*Listronotus setosipennis)* were imported on 15 September 2009 from South Africa for host specificity testing at Ambo, Ethiopia. The fast growing grasses are more effective in competing with parthenium than slow growing legumes.

Thrips-borne Tospoviruses

Virus diseases of various vegetable crops grown in India and a new virus disease of yardlong beans in Indonesia have been identified. *Iris yellow spot virus* (IYSV) transmission efficiency by *Thrips tabaci* in onions was conducted and found that transmission of IYSV can occur in as little as 15 minutes feeding time on the onion plant. Since virus detection in single thrips by serological techniques like ELISA using virus-specific antibodies is not reliable due to small size of thrips, a RT-PCR assay for the detection of tospoviruses in single thrips has been developed. The usefulness of FTA cards for the collection, shipment and identification of viruses in different crops has been evaluated. Several tomato cultivars and hybrids have been screened for resistance to *Peanut bud necrosis virus* in India. Rouging *Peanut bud necrosis virus* infected tomato seedlings in the nursery and transplanted field has been identified as an effective technique in controlling this disease. Studies on *Tobacco streak virus* (TSV) show a seed transmission rate of 10%. The results also showed that the rate of seed transmission is higher in hybrid seed from plants with self pollination.

Insect Transmitted Virus Diseases

Comprehensive information on viruses of solanaceous and cucurbit vegetable crops has been compiled at Virginia Tech by a graduate student from Jamaica using published literature and on-line resources in plant virology. Diagnosis of plant viruses relies upon the use of serological or molecular methods that require trained persons, costly reagents, and well-equipped laboratories. This project focused on building capacity, both in facilities and in training, and in testing samples taken from host countries. Identified *Tomato yellow leaf curl Mali virus* (TYLCMLV), *Tomato leaf curl Mali virus* (ToLCMLV) and *Pepper yellow vein Mali virus* (PepYVMV) on tomato and *East African cassava mosaic virus* (EACMV) on cassava in Burkina Faso; *Okra yellow crinkle virus, Cotton leaf curl Gezira virus, and Cotton leaf curl Gezira betasatellite* in Mali; *Tomato yellow leaf curl virus*, *Tomato severe leaf curl virus* (ToSLCV), *Tomato mosaic Havana virus* (ToMHV), and tomato chocolate spot virus in Guatemala; and TSWV on pepper and tomato in two facilities, CMV on pepper in one facility, and PMMoV on pepper in Dominican Republic; and *Tobacco etch virus* (TEV) from hot pepper in Jamaica. The implementation of a 3 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 *Tomato yellow leaf curl virus* (TYLCV) in Dominican Republic. The variety PY 163 showed resistance to virus diseases of peppers in Honduras. Disease severity ratings were reduced by as much as 93% in peppers treated with *Bacillus* UWI-3 and *Pseudomonas putida* NCIMB 9571 in Jamaica.

International Plant Diagnostics Network

The International Plant Diagnostics Network (IPDN) continues to become established 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 and the US. The portal is being modified based on these evaluations and a revised version will be released in late 2008. Training in the use of the DDIS/CIMS was conducted in East Africa and Central America for 59 individuals, who were also trained in plant/insect pest diagnostic techniques, including modern methods such as serology and PCR. Two first reports of diseases (bacterial wilt of tomato in Benin and banana xanthomonas wilt in Burundi) were submitted for publication in international journals.

Information Technology and Database

This global theme program collaborated with the regional programs, Southeast Asia on cocoa pod borer, West Africa on whitefly, Central Asia on training, and Latin America and the Caribbean on CaribbeanPestWatch. Software applications developed include: GlobalPestInfo, CaribbeanPestWatch, PestMapper, and PestNewViewer.

Impact Assessment of the IPM CRSP Programs

Collaborating with scientists in the regional programs, the common components of the methodology to be applied in each region are: a) baseline surveys; b) collection and budgeting of experimental and price data in standardized formats; c) assessment of farmer adoption of IPM technologies; d) GIS and economic surplus analysis of market-level impacts of IPM; e) calculation of poverty impacts; and f) data collected on changes in pesticide use for farmers who adopt IPM technologies, estimation of changes in environmental and human health risks and their perceived value. Development of a consistent, integrated, spatially-referenced and tabular datasets for IPM impact assessments for 15-20 commodities locally, nationally, regionally, and globally will continue, led by Minnesota and IFPRI (and also using funds from other sources) in order to address a larger set of commodities than would be possible with IPM CRSP resources alone. Intensive research collaboration on insect and disease modeling and data collection was fostered by visits to IRRI, CIAT, CIMMYT, CSIRO and the University of Queensland, in addition to consultation with the USDA Cereals Disease Lab at the University of Minnesota. Virtual Georeferenced Elicitation Tool (V-GET) pest and disease data collection and modeling efforts have expanded to include significant and on-going participation from private industry in addition to IARC collaboration. Results of the economic assessment of the IPM CRSP programs were reviewed and presented.

Program Impact Areas:
IPM CRSP FY 2009 activities have produced the following outputs:

Long-Term Projects
57 – Long-term degree students (32 men and 31 women)
33 students in B.S. program
91,438 – Short-term training participants
57 – Workshops
82 – Meetings
117 – Training sessions
17 – Field day/Demonstration/Exhibition
35 – Seminars/Symposia/Conferences
2 – Surveys
28 – Poster Presentations
239– Publications
5 – Abstracts
94 – Presentations
28 – Posters
1 – Annual report

Training and Institutional Development: IPM CRSP research activities contributed to short and long term training. 57 graduate students from 24 countries were involved in long term degree training. Of these, 50 were from developing countries and 7 were from the U.S. There were 29 men and 28 women students who were working on 25 Ph.D. and 32 M.S. degrees. There were 33 students in the B.S. program. Graduate students were majoring in Agriculture (12), Integrated Pest Management (13), Agricultural/ Applied Economics (7), Plant Pathology (4), Entomology (6), Crop Science/ Crop Protection (4), Plant Virology (2), Horticulture (2), Gender Issues (1), Plant Biotechnology (1), and Weed Science (1), Insect Pathology (1), Sociology (1), Landscape Ecology (1) and Plant Ecology (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, Sarah Hamilton	Carmen Suarez-Capello Mauricio Rivera, Alfredo Rueda, Danilo Vera.	Virginia Tech, Pennsylvania State University, Florida A&M University, Purdue University, University of Denver, Zamarano, FHIA
Regional IPM for East Africa	Uganda, Kenya, Tanzania	Mark Erbaugh	Dan Taylor, Sally Miller, J. Kovach, Greg Luther, Andy Roberts, Matt Kleinhenz	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, 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, R. Srinivasan	Rezaul Karim, Nutan Kaushik, S. Mohnkumar, V. Balasubramanian, R. Samiyappan B.Y. Gyawali, Luke Colavito	Pennsylvania State University, Virginia Tech, IRRI, AVRDC, The Ohio State University, Bangladesh Agricultural Research Institute, Tamil Nadu Agricultural University, 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, 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	Nurali Saidov, Murat Aitmatov, Barno Tashpulatova	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, Steve Atkins, 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
Management of Thrips-Borne Tospoviruses	India, Indonesia, Uganda, Uzbekistan	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, C.M. Deom, 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
International Plant Diagnostic Network	West Africa, East Africa, Central America	Sally Miller	Sue Tolin, Carrie Harmon, Bob Gilbertson	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
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, Aunu Rauf	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	All collaborators	Virginia Tech, University of Minnesota, IFPRI, CIMMYT, CIAT, IRRI, IITA and CSIRO

For a complete list of participating institutions refer to Appendix B

Phase III Long-Term Programs

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

Jeff Alwang, VirginiaTech

Development of early test to evaluate cocoa resistance to frosty pod and witches´ broom diseases

Resistance is a major selection trait in cocoa breeding programs. An efficient resistance test is fundamental to guide breeding programs. An early resistance test is fundamental to speed up and scale up those breeding programs. Therefore any effort to find such a test or to standardize the existing ones constitutes a key focus of this cocoa research program and concentrated efforts with the IPM CRSP resources have been made during this year.

Inoculation of germinated seedlings up to three weeks of age with a spore suspension (spraying tests named “holiday modified” and “belt spray”) or a 1cm^2 agar block (“agar block test”) of basidiospores of the fungus have given the following results:

Moniliophthora roreri (frosty pod) does not infect vegetative parts of the tree and the symptoms found on seedlings are not consistent.

Bioassays carried out to establish factors that influence the plant response to *Moniliophthora perniciosa* (witches’ broom) inoculation on cocoa seedlings, comparing the three methods show that the size of the emerging bud and the spore concentration are the parameters to take into account to evaluate cocoa cultivars. Independent of the chosen method, the higher the spore concentration used the larger the incidence of the disease and the lower the incubation period, showing the aggressiveness of the Ecuadorian strain of *M. perniciosa*. This fact should be taken into account when testing cultivars for resistance to witches’ broom using any of these methods.

The sources of variability, i.e. methods, genotypes and concentrations, were significant for all the variables analyzed, with the exception of the size of the brooms formed.

Cocoa clones SCA 6 and 12, resistant to witches´ broom, have been considered in other trials/countries with all methods, while other two other clones, Gu 175 and CCN 51, are tolerant, and EET 95 has field tolerance.

Based on the results of this study, a protocol was developed for early testing of cocoa against witches’ broom.

Assessment of pathogens in cocoa/plantain-producing areas

Monitoring of cocoa-plantain farms from three localities-Virginia/Quevedo on the coastal plain, Guarumal/Mocache, low Andean hills and San José de Tambo, Bolívar province which is part of the Chimbo watershed (90, 120 and ±300 meters above sea level, respectively), was completed this year.

During this period the intensity of the main problems were recorded so that they could be related to physical, climatic and management influences. Evaluations during this year correspond to cumulative infection from dry season 2008 and rainy 2009, and in general around 20% lower incidence of pest and diseases were found in relation to prior year.

As expected, incidence and intensity of the problems were greater during the rainy season, with fungal agents being more active and causing more damage than insects (Table 1). The San Jose de Tambo and Guarumal sites, located at higher altitudes (120 and 300 meters above sea level) than La Virginia (<90masl), presented lower incidence of problems; indicating that temperature was the main variable. The information collected will be reviewed in context with socioeconomic parameters characteristics from those systems, in order to understand its biodynamics from the pest and disease point of view and the socio-economic impact on farmers. For example, in the Guarumal site where farmers were trained in IPM principles and disease management during 2008, disease incidence and severity recorded were lower in the last two seasons, than in the other two sites without any important changes in climate. Apparently, farmers are applying better management practices.

Major problems in cacao were moniliasis and witches broom, the former being more intense in San Jose de Tambo and the latter in La Virginia. Climatic, nutritional and management parameters are being correlated so as to develop ad-hoc IPM strategy for each of them. Other agents such as *Colletorichum* sp. on leaves, *Lasiodyplodia, Pestalotia* sp., *Cordana* sp. and *Ascochyta* sp. presented certain intensity during dry periods but seem to be mostly related to stress on the plants.

The situation was similar in plantain, with *Mycosphaerella fijiensis* (Black Sigatoka) and *Erwinia* sp. (bacterial infection) being the main diseases observed in these localities, followed by leaves spots caused by *Cordana* sp., *Colletotrichum* sp. and *Ascochyta* sp., respectively. The incidence of *Erwinia* sp. was next to 100 percent, during the evaluation period, however its damage was constrained to external vegetal tissue (pseudostem) and is related to poor state of the plants.

All agents are kept in our local collection and arrangements are being made to share specific identity and location with the governmental organization in charge of National Agricultural Health, for quarantine purposes.

The information obtained is being incorporated to the training modules tailored to deal with a prototype management of the factors that favor or inhibit spread of targeted diseases as a means for a more efficient IPM strategy for these pathosystems.

Table 1. Type and intensity (%) of phytosanitary constrains observed on cocoa in three sites from the coastal plain in Ecuador*. Pichilingue, 2009.

Phytosanitary problema	**La Virginia**				**San José de Tambo**				**Guarumal**		
	2007	**2008**		**2009**	**2007**	**2008**		**2009**	**2008**		**2009**
	Dry	**Rainy**	**Dry**	**Rainy**	**Dry**	**Rainy**	**Dry**	**Rainy**	**Rainy**	**Dry**	**Rainy**
Cladosporium sp.	0	50	10	70	18	100	100	100	30	30	30
M. roreri	0	80	0	80	12	100	15	100	60	0	40
Esqueletizador	0	100	0	100	0	100	22.5	100	80	0	80
Liquens	0	70	0	75	100	100	100	100	25	0	40
Colletotrichum in leaves	7	0	90	70	22	20	80	100	20	0	40
Cochinilla	0	10	0	35	0	30	0	60	0	20	0
Lasiodiplodia	55	0	0	60	43	100	0	100	5	0	30
Colletotrichum on pods	0	0	0	20	5	20	0	35	0	5	0
Nigrospora	0	0	0	10	0	80	0	70	7	0	0
Witches' broom	100	100	100	100	25	0	10	2			
Ephifites	25	55	50	80	60	70	100	70			
Pestalotia	12	0	0	25	25	0	0	0	0		
Phyisoderma	0	0	0	25	25	0	60	0	80		35

Evaluation of control alternatives for botrytis in black berry in the valley of Chillanes

A field study was conducted in the valley of Chillanes to measure the efficiency of the best *in vitro* fungicide applied every two weeks in plots managed with an INIAP-recommended IPM program compared to farmer´s technology (plant management and sanitation). A biological fungicide containing a mixture of *Bacillus* spp was applied 8 days before harvesting in INIAP with farmers crop management technology to avoid fungicidal residues on the fruit.

The disease was not severe during the dry season, reaching just 22% of infected fruits in the control plots. Under these circumstances, procloraz and *Bacillus* spp. were the most efficient treatments to control the disease. *Bacillus* spp. together with the INIAP crop management technology was enough to control the disease, however in farm crop management conditions procloraz appeared to be more efficient.

Disease management in the rainy season required better planning as it reached 75% severity in the control treatment with INIAP´s technology and higher in farmer's plot. *Bacillus* spp., procloraz and iprodione with disease severity of 38%, 49% and 53% respectively, were the most efficient fungicides with INIAP technology; however, all fungicides perform poorly with the farmer's technology. Disease management in the rainy season has not been achieved in the past in Chillanes; therefore, it is feasible to implement an adequate IPM management program.

Bacillus spp, was the most efficient fungicide in this study, which suggests that organic control of botrytis may be feasible with biological control agents (Table 2). Procloraz and iprodione are the most efficient for conventional black berry production; however, *Bacillus* spp. should be the base of botrytis control, even for conventional production, especially for near harvest applications.

An important contribution of INIAP technology is associated with increased fruit size. Although the number of fruits with the farmer's technology were higher than with INIAP´s the weight of fruits of the latter were higher possibly due to better sanitary conditions in the crop that permit that fruits to fill up completely. This was an important advantage farmers liked and encouraged them to adopt the technology.

Table 2. Percentage of infected fruits with botrytis and yield of blackberry in dry and rainy seasons in the evaluation of six fungicides with two crop plant management techniques to control botrytis. Santa Catalina, 2009

Fungicide	**Dry season**						**Rainy season**					
	Percentage (%) infected fruits		**Number of fruit per plant**		**Yield kg/plant**		**Percentage (%) infected fruits**		**Number of fruit per plant**		**Yield kg/plant**	
	INIAP	**Farm**	**INIAP**	**Farm**	**INIAP**	**Farm**	**INIAP**	**Farm**	**INIAP**	**Farm**	**INIAP**	**Farm**
Plocloraz	13.2	10.2	1150	1325	4.6	4.0	49	92	675	100	2.7	0.30
Cyproconazole	15.1	16.9	1125	1225	4.5	3.7	83	84	225	206	0.9	0.62
Iprodione	-	16.9	900	1225	3.6	3.7	53	85	620	196	2.5	0.59
***Bacillus* sp.**	0.0	15.3	1325	1250	5.3	3.8	38	84	817	206	3.3	0.62
Himexazole	17.0		1100		4.4	--	60		520		2.1	--
Difeconazole		16.9		1225		3.7		66		440	--	1.3
Control	22	--	1150	--	3.5	--	75	--	320		1.0	--

Assessment of IPM packages for vascular wilt, late blight, root-knot nematode and fruit borer control of common naranjilla in Ecuador

During validation of the IPM programs, late blight was not a constraint, although in previous seasons this disease caused complete yield losses in the same plots. Absence of the disease may be due to change in climatic conditions. In this season rainfall and relative humidity was significantly lower than in previous seasons, which might have interfered with spread. This result proves the inconsistency of late blight epidemics and the importance of climatic variables on disease build up. This requires further study.

Anthracnose was severe and the control efficiency of three fungicide rotation strategies was compared with the application of the organic fungicide *Bacillus* spp. The fungicide applications were done every two weeks.

The efficiency of the protectant fungicide Captan decreased after the third application and a systemic fungicide was necessary to improve disease control. Copper sulfate, azoxystrobin and triadimethon had similar effects and are suggested to be strategically rotated with Captan.

This sanitation method of removing the infected fruits from the plants was also considered in this study. Results obtained show (Table 3) that if the control strategies are done properly, the conventional strategies can yield high profits, even under severe epidemic conditions. When fields are not maintained sanitarily, other control measures are not very effective.

Grafting of common naranjilla onto *Solanum hirtum* is becoming a widely known technology being promoted countrywide throughout naranjilla areas. At present, the company PILVICSA that commercializes seedlings of horticultural crops is also commercializing grafted naranjilla plants. The demand for grafted plants is high and they are committed to producing 70,000 plants.

Segregating populations derived from F2 plants of five crosses between *Solanum quitoense* (naranjilla) with *Solanum felinum, Solanum vestisimun* and *Solanum hyporhodium* were studied to analyze and select the resistance to *F. oxysporum* and *P. infestans*. All varieties of *S. quitoense* used in these crosses were susceptible to the pathogens, while all accessions of other species in the crosses were resistant to both pathogens. From these crosses in the previous season 1067 F3 plants were evaluated to *F. oxysporum* from which 17 plants were selected with good agronomical potential. From these plants at least 1700 F4 plants will be evaluated to *F. oxysporum* and *P. infestans* (Table 4).

Table 3. Percentage of healthy fruits, yield, production costs and profitability of conventional and *Bacillus* control of anthracnose in Tandapi, Pichincha. Santa Catalina, 2009

Treatments	Percentage of healthy fruits (%)	Yield Kg/ha*	Global Income	Production costs	Profitability
C1	83,30	19131,04	18557,11	6607,23	11949,88
C2	93,95	17596,15	17068,27	6004,85	11063,42
C3	88,62	17706,14	17174,96	6121,52	11053,44
O1	54,41	12276,47	11908,18	7572,38	4335,80

*Five months harvest. The plant starts producing ten months after planting; spraying plan/treatment: C1: captan, captan, captan, asoxistrobin, captan, asoxistrobin, asozistrobin; C2: captan, captan, captan, copper sulfate, captan, copper sulfate, copper sulfate; C3: captan, captan, captan, triadimefon, captan, triadimephon, triadimethon; O1: *Bacillus spp*

Table 4. Reactions to *Fusarium oxysporum* and *Phytophtora infestans*, of segregating plants of five crosses between *Solanum quitoense* (naranjilla) with *S. hiporhodium, S. felinum* and *S. vestisimun.* Santa Catalina, 2009

Cross	F2 plant population	F3 plant popultion	F4 plant population
S. quitoense (var. Dulce) x *S. hyporhodium* x *S. quitoense* (var. Dulce)	10	119	200
S. hyporhodium x S. quitoense (var. Baeza)	15	241	100
S. felinum x *S. quitoense* (var. Dulce) x *S. quitoense* (var Dulce)	12	276	200
S. quitoense (var. Baeza) x *S. vestissimun*	5	227	500
S. quitoense (var. Dulce) x *S. vestissimun*	20	204	700

Number of segregants for evaluation against *F. oxysporum* and *P. infestans*

Refine IPM package for mixed cultivation in plantain, Ecuador

This trial was set up to investigate the merits in the use of plantain as shade for cacao as far as diseases are concerned. The trial also attempted to compare the benefits of different spatial arrangements of cacao and plantain as an intercropped system. Cocoa – plantain intercropping systems have been practiced for generations without examining their biological and economic advantages. By standardizing the spatial arrangements of the cacao and plantains in the present investigations, it will be possible to determine the best combination that can be recommended to farmers.

Cocoa yield stabilized this year making it possible to evaluate production and incidence of diseases. Pod losses due to the combined effect of Witche's broom and Moniliasis and cherelle wilt (a physiological defect) were nearly threefold higher in single cocoa plots than in any of the combinations.

The better canopy closure in cocoa – plantain single rows and diamond design, favor sanitation of the plants, even with plantain, showing fewer lesions than in the other treatments.

As for plantain there is low disease incidence and slightly better yield in the double row system, although it is not statistically significant for the other two mixed systems (Table 5). As a consequence, considering the ecological and epidemiological advantages there is sound reason to recommend them for new plantings.

Using information derived from these activities, interactive training modules have been prepared and adjusted with collaborative farmers in order to convey information about IPM, nutritional principles and the fungal concept of infection within the life cycle of both *Moniliophthora* spp. in cocoa.

Table 5. Levels of signification of Diseases Index (IE) and Area Under Diseases Progress Curve (AUDPC) for Black Sigatoka disease on plantain in a cocoa-plantain system. Pichilingue, 2009

Treatments	IE	AUDPC
Cocoa-plantain double rows	18,5 a	867,4 a
Cocoa-plantain single rows	19,2 a	885,3 a
Cocoa-plantain diamond	20,8 a	902,1 a
Single	23,5 b	1196,4 b

Values followed by the same letter within columns are not significantly different p=0.05 Tukey's multiple range test.

Communities of invertebrates present in leaf litter within plantain plantations were identified, evaluated, and measured. A network of taxonomy specialists was then set up to help on identification of the communities under study.

The main arthropod orders found in Las Tecas Trial during two years of evaluation (after establishment trial) were: Hymenoptera, Coleoptera, Diptera, Thysanoptera, Lepidoptera, Hemiptera, pseudoscorpions, spiders, mites, Collembola, Diplopoda, and Isopoda. All of these families were found in different populations (Table 6).

There were no significant differences in abundance of arthropods between the secondary forest "control" and the different cropping systems. Analysis by groups of arthropods (not shown) revealed that mites were by far the most abundant in all treatments (Table 7).

Richness and abundance of ant genera (*Formicidae, Hymenoptera*) were also analyzed. Ants are now widely used as indicators of environmental disturbance. Results also failed to show significant differences in either abundance or richness among treatments. However, ants were slightly more abundant in the secondary forest, and generic richness was slightly higher in the secondary forest and the old mixed farm. In this latter case, number of ant genera was highest in the parcels with the least human intervention.

Results so far found in this study demonstrate that the use of mixed systems with minimum or no use of pesticides may improve yield without much ecological disturbance on the land.

Table 6. Population of arthropods found in fallen leaves, cocoa, plantain, mixed cocoa – plantain, old mixed farm, and secondary forest in Quevedo area. IPM/CRSP project 2009.

Treatments	**Abundance**	**Average***
Cocoa-plantain double rows	5333	55,56 **a**
Cocoa-plantain single rows	4816	50,17 **a**
Cacao only	3998	41,65 **a**
Plantain only	3877	40,39 **a**
Secondary forest	3815	39,74 **a**
Old mixed farm	3537	37,22 **a**
Cacao – plantain Diamond	3387	35,28 **a**

***** Same setter within columns are not significantly different at $p <= 0,05$ as determined by Tukey HSD test.

Table 7. Population of arthropods found in intercropping based in Cocoa-plantain. Pichilingue 2009

Treatments	**Population of arthropods**
Cocoa-plantain double rows	4980
Cocoa-plantain single rows	4179
Cocoa-plantain diamond	3199
Single Cocoa	3199
Single Plantain	3011

During 2008 and early 2009, elite lines of *Bacillus* spp. that had passed preliminary tests, were evaluated as spray applications to small cacao trees growing under an over-story of large cacao trees infected with witches' broom. In this replicated trial 4 isolate lines of *Bacillus* spp. were evaluated on 4 Nacional clones of cacao as well as rootstock seedlings of IMC67. In the 2008 rainy season, *Bacillus pumilis* isolate ET reduced disease severity of witches' broom. ARISA analysis of the microbial community structure of bacteria colonizing these leaves indicated that application of this isolate displaced bacterial endophytes which were neutral in terms of plant health. Based upon the monthly disease ratings in the 2009 rainy season, there was no suppression of disease. The 2008 rainy season data demonstrated that disease suppression due to *B. pumilis* isolate ET was greatest in February and March, therefore disease suppression likely occurred.

In January 2009, a trial was initiated to determine whether the four elite *Bacillus* isolates could suppress cherelle wilt and cacao pod diseases. Experiments were conducted at two research sites: with 'Nacional' trees at the INIAP research station in Pichilingue, Ecuador and with 'CCN-51' trees at the Rio Lindo commercial farm near Pichilingue, Ecuador. Bacterial solutions were sprayed onto individual pods. At each experimental site 400 individual pods were sprayed, representing 80 replicates per treatment per experiment. For 'Nacional' pods, bacterial treatment did not significantly reduce incidence of cherelle wilt, frosty pod, or witches' broom when compared to control treatments. Black pod rot did not develop in 'Nacional' pods in this experiment. Bacterial treatments did not significantly reduce disease incidence of frosty pod or black pod rot in cultivar 'CCN-51'. Witches' broom did not occur on 'CCN-51' pods in this experiment. *Bacillus pumilis* ET significantly reduced cherelle wilt (p=0.044) by approximately 32% in this experiment. Similar control trends were found between 'Nacional' and 'CCN-51' pods treated with bacteria. Cherelle wilt was much more severe in 'CCN-51' trees (35-52% of pods) than 'Nacional' trees (2-12%), therefore pod losses to cherelle for 'CCN-51' were very high. Suppression of cherelle by *Bacillus* strain ET resulted in more healthy pods season long, though this difference narrowed as diseases developed on these additional pods. Even though applying *Bacillus* spp. did not significantly reduce disease incidence in these trials, this is the first report of treatments reducing cherelle wilt.

Evaluation of crop rotation for management of purple nutsedge, *Cyperus rotundus*.

A study was conducted to evaluate the ability of *Dolichos lablab*, *Mucuna pruriens*, *Vigna sinensis* and *Sorghum bicolor* as cover crops to manage nutsedge and root-knot nematode populations. The treatments were the three legumes in monoculture, a mixture of *D. lablab* and *M. pruriens*, and a control without a legume, all with and without sorghum. No differences were found between legumes. However, nutsedge population were reduced in 27% in treatments without sorghum, compared to treatments with sorghum were there was no reduction. Nematode population in plots with sorghum (75%) was higher than plot without sorghum (66%).

Efficacy of miticides with ovicidal effect as pre-plant treatment for disinfestation of mites in strawberry planting.

In 2008, a trial was established to evaluate the effect of clofentezine (Acaristop®) and spiromesifen (Oberon®) as pre-plant treatments of strawberry planting material for control of the strawberry mite, *Phytonemus pallidus*. No mites were detected in the plants treated with clofentezine and spiromesifen, whereas mites were found in the untreated control.

Demonstration plots of strawberry mite management with growers.

Most growers are reluctant to accept the use the hot water treatment for control of mites in planting material of strawberry in spite of the encouraging results obtained during field trials. Apparently, they find the procedure too complicated. As a result, there were only two growers who participated by providing land for the demonstration plots. The hot wáter treated plants were free of mites, which did not happen with the chemically treated part of the plot.

Development of an IPM-based strategy for management of the *Thrips tabaci-Alternaria porri* complex in onions in Honduras

Component 1. Correlation between sticky trap catches and direct counts of onion thrips. H. R. Espinoza-FHIA.

The study was completed in March 2009. The results did not show a clear and consistent correlation between trap catches and direct counts that could be used as the base for forecasting model. It is hypothesized that the behavior of thrips populations in persistently favorable conditions for their multiplication does not permit the use of trap catches as a descriptor to use in forecasting population dynamics. Therefore, it was concluded that monitoring for onion thrips, under local conditions should be done by direct counts on the plants.

Component 2. Chinese eggplant interplanted with sunflower to monitor the populations of beneficial insects. H. R. Espinoza-FHIA.

The plots were established in January and harvest of the first commercial grade fruits started at the end of March. The plot enriched with sunflower and *Vigna* has consistently had more predators such as reduviid, anthocorid and geocorid bugs, coccinellid beetles and lacewings. In general, the pressure of *Thrips palmi* has been low.

Legumes as rotation crops for the management of soilborne pests in tomatoes, sweet potatoes and other horticultural crops

Component 1: Management of root knot nematode, *Meloidogyne* spp., in sweet potato. F.J. Díaz and D. Perla.

The study was conducted between August 2008 and April 2009 at a commercial farm in El Jicaral, Departamento of La Paz as part of a series of studies to evaluate, a) the effect of cowpea cultivars (introduced from UC-Riverside) used as rotation crop for the management of root-knot nematodes in a nematode infested soil, and b) its subsequent effect, nematode- and production-wise, on a commercial crop of sweet potato grown immediately after on the same soil. At the end of the cycle of the cowpea the use of the introduced cultivars CB-27, CB-46, and CC-85 had reduced the populations of root knot nematodes to minimum levels in comparison to the traditional rotation with sorghum and to the use of a local variety of cowpea together with application of the nematicide oxamyl, applied 35 days after sowing. In the follow-up crop of sweet potato the yield of exportable roots registered in plots previously planted with the cowpea varieties was as much as 4 times higher than the yield registered in plots where no cowpea had been planted, where the traditional practice (use of sorghum as rotation crop) was applied, and/or where the local variety plus oxamyl had been used. The favorable results obtained after two field studies carried out since 2007 show the potential of the resistant cowpea varieties to be used as rotation crops not only in fields where sweet potato is produced but also in soils where root knot nematodes represent a threat for the production of other horticulture crops in the Comayagua Valley and other important vegetable growing areas of Honduras. In order to make the technology available to the growers, communications have been submitted to the original sources of the material (UC-Riverside) to obtain permission to distribute seed to growers. The use of this practice offers a new, cheap and environmentally friendly alternative for control of the root-knot nematode to the local growers.

Component 2. Determination of species of the root-knot nematode (*Meloidogyne* spp) occurring in crops grown in Honduras. F. J. Diaz

This activity is an outgrowth of the initial project, which was focused solely on the use of rotation crops for management of the root-knot nematode. Further review of the literature revealed significant differences in the response of the species of the root-knot nematode to crop rotations as a means of control; thus, the success of the cowpea as a rotation crop may be limited by the species of *Meloidogyne* that occurs in the soil. Contacts were made with Dr. Paula Agudelo, a nematologist at Clemson University who has collaborated with FHIA in the past and an agreement was reached to determine the local species using morphological characters and molecular analyses. Between December/08 and May/09 several sample collection trips were made and 11 samples were collected, representing 9 zones of the country and 10 crops (banana, plantain, lulo, tomato, eggplant, cowpea, lettuce, pepper, watermelon and melon). The samples were submitted to Clemson University on May/29 and they are being analyzed.

Mechanical control of papaya fruit fly *Toxotrypana curvicauda*

Thermal mesh bags and pieces (35 × 25 cm) were evaluated as physical control and compared to a chemical control and a control with no treatment. Using thermal mesh bags or pieces reduced fruit damage in 80 % and 70%, respectively. Whereas, chemical control reduced 42% fruit damage.

Optimization of parameters for the application of *Heterorhabditis bacteriophora* for the control of *Spodoptera frugiperda* in corn, Zamorano, Honduras.

Entomopathogenic nematodes have a wide host range. The species *Heterorhabditis bacteriophora* is an entomopathogenic obliged infective juvenile stage. The objective was to optimize the application parameters of *H. bacteriophora* for the control of *Spodoptera frugiperda* in corn, performing tests to determine the effect of pH, filters and nozzles on the survival of the nematode. To measure the effect of pH was regulated water pH using hydrochloric acid to acid pH (4.0 - 6.5) and potassium hydroxide for alkaline (7.5 - 9.0). The nematodes were counted before they were exposed to different pH and then at 5, 10, 24 and 48 hours. Mortality was 22% at neutral pH, 51% at pH 4.0 and 52% at pH 9.0. For the pressure test, pressure (30, 60 and 110 psi.) and nozzles (flat fan and hollow cone) were counted at 1 and 5 hours after the exposure at the lowest mortality (14%) with hollow cone nozzle (Teejet TXVS - 12) a pressure of 30 psi and higher mortality rate flat fan (Teejet 11004) to 110 psi (20%). In the trial to measure the effect of slot-type filters, 50 and 100 mesh, sampling at 10 minutes and 2 hours after application, with 100 mesh filter passed only 50% of the nematodes of the initial concentration, with the slotted spent 87% and 50 mesh filters spent 96% of the initial concentration. The field was effective in doses of 90 million nematodes per hectare with 100% control.

Development of a method of rearing of *Orius insidiosus* in Zamorano, Honduras.

Orius insidiosus is an important polyphagous predator of agricultural pests as thrips, mites and whiteflies. It is used commercially in other parts of the world for cultivation in greenhouse and open field. The study objectives were: to develop the rearing method of *O. insidiosus*, determining which of the two crops (sweet potato and beans) provides better conditions for oviposition and hatching of *O. insidiosus* eggs under laboratory conditions and evaluate three diets based on *Sitotroga cerealella* eggs, pollen and *S. cerealella* with pollen for the rearing of *O. insidiosus*. The study was conducted in the herbarium at Zamorano, Honduras in September 2008, with a temperature range of 20 to 25^{o}C and 75% relative humidity. We evaluated sweetpotato cuttings and bean pods measuring the amount of eggs oviposited in them and the hatching of *O. insidiosus*, both cuttings showed the same average oviposition (116 ± 36), but the hatching of eggs was 89% in the sweetpotato cuttings and 60% in beans pods. The survival of adults at 20 days was low in all three diets, this result was probably influenced by temperature, relative humidity and photoperiod conditions were not monitored during the study.

Host crops for reproduction of whitefly in Zamorano, Honduras.

The greenhouse whitefly (*Trialeurodes vaporariorum*) is one of the hardest pests to control, which has led to research into alternatives of pesticides to control but this requires that the insect pests be studied first. The aim of this study was to evaluated host crops such as eggplant, sweet potatoes and beans on the development and reproduction of the whitefly. The treatments were composed of eight plants of each crop planted inside cages made of PVC pipe of 5.08 cm in diameter and 1.25 m × 1.25 m × 2 m covered with antivirus mesh. Plants were exposed to a density of 40 whiteflies per cage and set three repetitions of each treatment. Every three days for a period of 21 days, the leaves of the upper, middle and lower plants of each treatment were sampled. The most favorable host for crop production and whitefly was eggplant this had the greatest amount ($P \leq 0.05$) of eggs, nymphs of first stage and second-instar nymphs per leaf (5.70, 1.43, and 1.28, respectively) compared to sweet potato and beans. It was determined that the eggplant was more favorable for the reproduction of the whitefly the preference for oviposition and numbers of individuals of each instar present in strata of different heights of the eggplant.

Oviposition of *Tetranychus urticae* (Acari: Tetranychidae) on three host crops in Zamorano, Honduras.

Tetranychus urticae is one of the main pests in vegetable and fruit crops. Biological control strategies have been implemented because it has become resistant to chemical acaricides therefore caused a high economic and environmental cost. The objective was to determine which of the three crops (beans, cucumber and sweet potato) served as host of *Tetranychus urticae* better for mass production. The leaves of crops were extracted and infested with one female and one male for 24 hours with *T. urticae* on leaf disc of 5 cm. in diameter superimposed on wet paper towels in Petri dishes. The oviposition rate was evaluated daily, number of eggs per female and number of nymphs I, II, III per female, 15 replicates per treatment were evaluated for eleven days, using a Completely Randomized Design. The number of eggs per female in cucumber and bean was 95.6 ± 16.9, 89.4 ± 8.5 respectively, while in sweet potato was only 43.6 ± 4.5. The number of nymphs I, II, III per female was 69.6 ± 15.2 and 66.7 ± 8.1 respectively in cucumber and bean and sweet potato was 31.5 ± 5.3. With these laboratory results cucumber and bean crops can be considered as the best hosts for the production of *T. urticae*.

Evaluation of four strains of *Trichoderma* sp. to control *Fusarium* sp. in watermelon.

Special Project Program in Agricultural Engineering, Zamorano, Honduras.
Vascular wilt in watermelon is common and is caused by fungal pathogens such as *Fusarium* sp. Trichozam ® is currently used (based on biological fungicide *Trichoderma sp.*) in a wide variety of horticultural crops. This helps to reduce the use of agrochemicals and production costs, and increase the yield. The objective was to evaluate six combinations of four strains of *Trichoderma sp*. (EAP Zamorano commercial strain, isolates obtained from Choluteca and in Costa Rica, and *Trichoderma koningii*) and two combinations in laboratory and greenhouse seedlings for control of *Fusarium* sp. in watermelon plants. In the laboratory: growth, production and viability of conidia, antagonism between strains of *Trichoderma* sp. and control of *Fusarium* sp were evaluated. We chose the two best combinations of *Trichoderma* sp. based on laboratory results and these were compared with Trichozam ®, there was a chemical and null check test. Seedlings were evaluated in length, diameter and root volume, and production of fresh and dry roots and foliage. In the greenhouse incidence and mortality was evaluated as of *Fusarium* sp., plant height, and number of fresh and dry foliage, length, diameter and volume of roots. Isolations were made from the roots and soil to determine the presence and behavior of each combination. The combination was more antagonistic capacity of the strains Zamorano + Choluteca. The combinations showed no antagonism in vitro were Zamorano and Choluteca + *T. koningii*. In seedlings that the combinations were better than other treatments in all variables measured, but between the combinations there were no differences. Combinations in the greenhouse had lower incidence and mortality from *Fusarium* sp. and greater plant height. Leaf fresh weight Trichozam ®, the control and chemical control behaved the same. In isolates from soil and roots the presence of each of the strains that make up the combinations in the greenhouse were found.

Detection of main diseases affecting papaya plantations in Honduras
The objective of this study was to identify and systematize the symptomatology of the main diseases affecting papaya plantations in Zamorano. Samples were collected from the organic agriculture fields where plants showed the following symptoms: yellowing leaves, necrosis, rotting and abnormal growth. Leaves, stems, roots and fruits were analyzed. Fungi were analyzed by characterization of reproductive spores, bacteria by biochemical test and phytoplasm by DNA extraction. Fungi isolated were

Colletotrichum sp., *Curvularia* sp., *Rhizoctonia* sp., *Alternaria* sp., *Oidium* sp., and *Fusarium* sp. Bacteria found were *Erwinia* sp. and *Xanthomonas* sp. No phytoplasm was detected.

Management of the eggplant fruit borer *Neoleucinodes elegantalis* (Lepidoptera: Pyralidae). H. R. Espinoza.
Between February and March pheromone traps were deployed in two sites for six weeks without any moths being trapped in the Comayagua Valley. This pheromone, obtained from a supplier in Costa Rica, was synthesized based on studies conducted in South America and it is suspected that it may come from a different species, since the one reported in Honduras does not feed on tomatoes as the species reported from Colombia, Venezuela and Brazil. This may be the reason for the absence of catches. Fruits of wild species of *Solanum* collected in Comayagua have not produced any larvae.

Manual for prevention of *Phytophthora* spp. root and crown rot of avocado in nurseries and young field plantings
Planting of the "Hass" cultivar of avocado is strongly promoted by different parties, including FHIA and FINTRAC through the Millennium Challenge Account initiative and the USAID-funded RED project. The crop may become an important source of cash for growers and it also substitutes for imports currently being brought from México and Guatemala. The most important problem for successfully establishing the groves is the death of high numbers of plants caused by species of the soil borne pathogen *Phytophthora*, resulting in rotting of the roots and crowns of the plants. In most cases the problem is carried from the nursery where the plants are produced. A practical guide for prevention of losses of avocado plants due to soil borne problems is being prepared.

Transfer of plantain and vegetable IPM programs from Ecuador and Central America to other areas of the Caribbean
A number of networking activities that increased the profile of the CRSP throughout the region was conducted.

From October 8 thru 10/2008 the XI International Congress on IPM of the Mesoamerican region was held in Tegucigalpa. The event registered the assistance of 406 persons (102 female and 304 male) from 14 countries of the Mesoamerican and Caribbean región. There were presented 83 research papers, 15 posters, 4 symposia and 12 stands assembled by the seed and agrichemical companies.

Technology transfer activities, in which teachers, parents, and students of a secondary school in Guatemala learned snow pea biology, ecology, and IPM, and during which they produced snow peas under the pre-inspection protocol developed by the IPM CRSP, was judged a success by all. The school system has requested and received additional field support from Jorge Sandoval and others in Guatemala, and it is anticipated that the program will be scaled up to additional schools. This activity was transferred to Honduras during the XI Congress.

During summer, 2009, University of Denver M.A. candidate Elizabeth Crawley conducted a field study of 43 farmers, three-fourths of whom collaborate with FHIA extensionists on IPM and production of Asian vegetables in the Comayagua Valley. Ms. Crawley visited 35 farmers over a two-month period.

Preliminary findings:

- Farm sizes ranged from 0.5 mz to 11 mz and averaged 2.8 mz
- Non-traditional crops under production during this season included: eggplant (Chinese, Japanese, Indian, and Thai); calabash; okra (Thai and Chinese); bitter melon (Chinese and Indian), and cucumbers
- On average, fertilizers were applied twice weekly.
- On average, farmers applied two-to-three pesticides weekly, mixed together
- All chemicals were applied on a rotating basis
- A total of 42 pesticides were applied during the month of interviews. Most frequent applications: Monarca 11.25 SE, Newmectin, and Sunfire 24 SC
- Average costs for fertilizers for one month: 3942 Lempiras
- Average costs for pesticides for one month: 11549 Lempiras
- Average farmer net income for the month: 40244 Lempiras

Income may be relatively low because historical factors served to depress prices and many farmers had planted, were applying inputs, but had yet to harvest.

Ecuador: working paper on household survey data from Chillanes/Guaranda to analyze determinants of IPM adoption, crop choice and participation in higher valued markets has been drafted.

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

Mark Erbaugh, Ohio State University

Development of IPM research programs for tomato: Uganda

Evaluation of adoption of IPM technologies in Busukuma, Wakiso District

R. Namirembe-Ssonko, F. B. Kyazze, S. Kyamanywa. Z. Muwanga., M. Erbaugh. S. Miller., G. Kovach, M. Klienhentz, G. Luther

To assess adoption of tomato IPM interventions 60 farmers were interviewed. Of these, 20 were IPM project participants, 20 were recruits by the project participants, and 20 were non-project participants. Data collection variables include household characteristics, pests and diseases of tomato, knowledge and source of IPM information, IPM components, perception and preference, benefits and challenges of IPM, and suggestions for improvement.

Tomato is a primary cash crop to over 70% of all the study participants. Over 70% of the participants can define IPM as modern farming practices of tomatoes with less pesticide use.

The variety MT56 was the most preferred component of IPM because it is high yielding, resistant to bacterial wilt, has a long shelf life, and produces big fruits.

Benefits of the tomato IPM package, as perceived by participants, included: reduced use of pesticides; income during the dry season; improved inputs (seeds and advice); better quality and market for tomatoes; higher yielding tomatoes; took less land to grow more tomatoes; IPM tomatoes have longer shelf life and can wait for better markets; reduced cost of production; received more visitors to see tomatoes.

Challenges of the tomato IPM technologies as perceived by the participants: There are other tomato diseases (other than bacterial wilt) and pests are still prevalent; pesticides are expensive; labor intensity in land preparation; specialty market not always available; sometimes material for mulching and staking hard to find; termites attack mulch and stakes; lack tomato variety MT56 (not found in input shops); staking and field measurement tedious.

Suggestions on how to make the IPM package more attractive: need more information on premium markets; tomatoes should not be planted on ridges; trays for seedlings should be replaced by planting in bed; reduce spacing for staked tomatoes; use more manure; make variety MT-56 available on open market.

Assessment of the impact of tomato IPM packages on tomato production

J. Bonabana-Wabbi, B. Mugonola, R. Namusisi, S. Kyamanywa, J.P. Egonyu, R. Wekono , D. Taylor, M. Erbaugh, Z. Muwanga

Data obtained from a model tomato farmer and marketing middlemen operating in Busukuma was augmented with economic data collected in 2008. These data included tomato yield, price of output, area under production, number of chemical sprays applied and cost of chemical inputs. Farm revenue obtained as a product of output volume and output price was compared with the cost of chemical sprays. A comparative analysis of profitability was done across different management systems – 2 farmer practices and the recommended IPM practice to assess the monetary impact of tomato IPM in the area.

Middlemen paid farmers between 1,000 – 1,200shs per kg of tomatoes. Tomatoes in the market were sold by the box with large boxes containing approximately 100kgs. At farmer level, smaller boxes were used each containing between 20-25kg of tomatoes. Farmers who did not practice IPM sprayed between 12-24 times a growing season. In the worst-case scenario when they spray 24 times, the cost of sprays amounts to 2,352,000/- with no significant yield increment.

IPM practices have the potential to substantially increase farmers' net incomes through more harvestable tomato. Analyses indicate that both the yield advantage and the reduced-cost advantage (in terms of number of sprays) lead to higher net revenue for IPM-practicing tomato farmers (Table 1).

Table 1. Benefit of IPM practice over farmers practice

	Farmer Practice (@24 sprays) (UShs)	Farmer Practice (@12 sprays) (UShs)	IPM Practice (@ 3 sprays) (UShs)	Difference (using best-case scenario) (UShs)	Difference (using best-case scenario) ($)
Revenue/ha	1,852,500	1,778,400	2,845,440	1,067,040	534
Costs/ha	2,352,000	1,176,000	294,000	882,000	441
Profit (UShs/ha)	(499,500)	602,400	2,551,440	1,949,040	975
Profit ($/ha)	(249.75)	301.20	1,275.72	975	

Tomato: Kenya

Effects of pest management on insect and disease incidence and their economic benefits.

M.M. Waiganjo; S. Kuria; M. Erbaugh, J. Kovach, S. Kyamanywa

Trials were conducted on-station at KARI-Thika to test nursery protection using insect proof screen house and need based pesticide application of bio-pesticides. 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 and control as the main plots.

The treatments were IPM practice - Pest scouting and need based pesticide application of Bio-pesticides, namely B.t, Dipel® alternated with neem and Nimbecidine® and farmer practice involving weekly application of fungicide (Mancozeb®), fortnightly insecticide application (Dimethoate alternated with Deltamethrin (Decis®), and an untreated control with no insecticide application.

Arthropod pest population was low while fungal diseases, especially late blight, *Phytophthora infestans,* and early blight, *Alternaria solani*, were prevalent. The insect pests recorded on tomato crop included aphids, whiteflies, thrips, stinkbugs, leaf miners, bollworms and blister beetles. The insect pest species varied with season. The untreated control had the highest whitefly population score and bollworm damage (44.2%). The farmers practice had the lowest whitefly, aphid and thrips population in both the first and second season. Beneficial insects were recorded only from the IPM and untreated plots. These included ladybird beetles and the aphid parasitoid *Aphidious* sp. Whitefly populations were highest in farmers' practice despite routine insecticide application. However, aphid populations were low in farmers' practice throughout the season. Spider mite populations started building-up after the fruiting stage, but then the pest was adequately controlled through application of Dimethoate alternated with Cypermethrin. Other pests recorded from the tomato crop were thrips, leaf miners, coreid bugs, weevil and flea beetles. Ladybird beetles were the major beneficial insects observed in the tomato field.

The mean total yield differed significantly within the treatments. Farmers' practice had the lowest mean fruit damage (25.40kg/ha) and the highest marketable yield (2,527. 69Kg/ha) while the untreated control plots had the highest mean fruit damage (142.6kg/ha) and the lowest mean marketable yield (258Kg/ha).

Economic analysis revealed that IPM practice resulted in higher economic benefits when staking or mulching was applied in tomato production. The farmer management option recorded the highest pest management cost (116,000KSh/Ha) which lowered the economic benefits to 35,661KSh/Ha as compared to 41,599.20KSh/Ha and 40,783.80KSh/Ha in staking with need based pesticide application and grass mulching with need based pesticide application, respectively.

Most insect pests (aphids, stinkbugs, thrips, spider mites, leaf miners and blister beetles) except whiteflies were fewer in the farmer practice plots. The population and diversity of natural enemies (spiders, lacewings, ladybird beetles etc) was scarcer in the farmer practice where broad spectrum pesticides were applied than in the IPM and untreated control plots. IPM practice resulted in higher economic benefits when staking or mulching was applied in tomato production. The farmer management option recorded the highest pest management cost and consequent low economic benefits compared to IPM practice.

Evaluation of Tomato Breeding Lines for Resistance/Tolerance to bacterial Wilt

S. Kuria; M.M. Waiganjo; C.M. Kambo., C.Njeru, M. Erbaugh and J. Kovach.

Trials were conducted on-station to evaluate five locally developed tomato lines (155-28,193-2, 81-1, 155-18, 193-31), one introduced variety (MT56) and two commercial varieties (CALJ, Onyx) at KARI-Thika. A similar trial was repeated at KARI-Mwea with four locally developed lines, MT56 and two commercial varieties (Onyx and Valoria). One month old tomato seedlings were transplanted in a field that was a wilt hot spot. The trial was laid in a Randomized Complete Block Design of eight treatments replicated three times. Data collection was done fortnightly on the number of wilted plants.

The results showed that the local commercial variety (Onyx) had the highest (1.0) mean wilted plants (Table 2). Among the test lines, MT56 had the lowest mean number of wilted plants (0.06). The commercial variety, Valoria recorded 0.39 mean numbers of wilted plants and compared favourably with the developed lines (TKA155-18, TKA 193-2, TKA 81-1, and TKA 193-31) with 0.94, 0.89, 0.39, and 0.56.

Developed lines (TKA-192-31, TKA 155-18 and TKA 81-1) and MT56 demonstrated a high degree of tolerance to bacterial wilt. MT56 had a very poor shelf life and a round shape which made it unpopular for the local market. It is suggested that MT56 be used as a rootstock in grafting trials in Kenya to reap its benefits against the bacterial wilt.

Table 2: Mean number of wilted plants/plot and yield of each cultivar

Code	Treatment	Mean no. of wilted plants	Yield (t/ha)
1	TKA 155-18	0.94	26.63
2	TKA 193-2	0.89	26.67
3	TKA 81-1	0.39	26.67
4	TKA 193-3	0.56	24.79
5	MT56	0.06	19.75
6	Valoria	0.39	24.00
7	Onyx	1.00	22.75

Introduction of tolerant/resistant varieties for evaluation against begomoviruses

M. M.Waiganjo, B.M. Ngari, S. Kuria; C.M. Kambo and C. Njeru

Three lines received from USA (Dr. Maxwell) are being tested against begomoviruses on-station at KARI-Mwea using the standard protocol for virus testing. The new varieties included var Lianera F1, Romeli F1 and San Miguel F1 hybrids. Recommended tomato production practices were followed apart from insect management. The experiment was laid out in a randomized complete block design consisting of five treatments, replicated three times.

The tomato plants were sampled weekly for insects and mites, starting in the second week after transplanting up to harvest time. Three leaves and flowers per plant were searched systematically for lygus bugs, bollworm, mites, whiteflies, aphids, spiders, thrips, lacewings, ladybird and syrphid larvae. Disease symptoms were also recorded based on scales 0-4 for early blight, late blight, bacterial wilt and virus diseases. During the harvest period, the total weight was recorded. No insecticide was applied during the entire growth cycle.

Whitefly population density was significantly higher in the local commercial variety (Riogrande and Onyx) compared with the resistant introduced varieties (Lianera, Romelia and Miguel hybrid). The resistant cultivars Lianera hybrid had significantly higher yield compared to the commercial varieties. The mean weight per plant differed significantly and was higher with variety. Lianera hybrid and the commercial cultivar Riogrande had significantly higher yields compared to the other variety (Table 3). The results confirm the characteristics of the test varieties as high yielding and resistant to the viruses by being unattractive to the whiteflies. There were no signs of tomato leaf curl during the entire growth period among the test varieties.

The introduced varieties had lower mean number of whiteflies compared with the local varieties. The first two varieties (Lionero hybrid, Romelia hybrid) were commercially acceptable due to their shape and size. These may be re-introduced for use as breeding stock or for tomato production in Kenya.

Table 3: The effects of varieties on arthropod pests of tomatoes

Variety	**Aphids**	**Lygus**	**Thrips**	**White flies**	**Bacterial wilt**	**Weight**	**meant weight (gm)**	**Fruit shape**
Lianero hybrid	1.00a	2.23a	2.20a	5.95c	0.090a	2141a	433a	Roma-shape
Romelia hybrid	1.152a	2.67a	1.60a	7.74ab	0.190a	1007a	209b	Roma-shape
San Miguel hybrid	1.00a	2.02a	1.84a	6.03bc	0.094a	1378a	282b	Blocky shade
Riogrande	1.152a	2.77a	2.42a	10.49a	0.120a	1794a	408a	Roma-shape
Onyx	1.035a	2.78a	2.46a	9.77b	0.177a	993b	170b	Roma-shape
p-value	0.647	0.133	0.210	0.008	0.697	0.008	0.0010	
LSD	0.2832	0.725	0.864	3.003	0.1795	722.4	115.5	
CV	32.2	35.3	49.9	45.6	38.2	69.8	54.2	

Testing screened-beds for production of disease free tomato transplants.

M. M.Waiganjo, S. Kuria, C.M. Kambo, C. Njeru

The aim of this trial was to evaluate the effect of screen house seedling production on whitefly infestation and transmission of TYLCV in tomato, to asses the effect of screen house seedling production on tomato yields and to compare the IPM practice with the farmers' practice. The trial was laid out in a randomized complete block design composed of four treatments replicated five times. Data collected included whitefly population density and other arthropod pests from the tomato plots during each sampling on 5 plants per plot using a 1-5 score rating, number of virus infected plants in a plot. Effect of disease on marketable yield among the treatments was assessed.

Disease and pest free tomato seedlings were obtained from the screenhouse without additional control measures. However, seedlings raised in the outdoor were infected with late and early blights *Phytophthora infestans* and *Alternalia solani* respectively necessitating fungicidal spray before transplanting. The seedlings were also infested by whiteflies, *Bemisia tabaci* and lugus bugs.

In the field, the screenhouse seedlings were generally more vigorous, less disease infected and had less whitefly infestation. The common insect pests observed included whiteflies, aphids, lygus bugs and red spider mites. The highest yield (34t/ha) was recorded from the seedlings raised in the screenhouse and IPM (Scouting for pests and two sprays of Bt (Dipel®) alternated with Deltamethrin) followed by the farmer practice (Dimethoate alternated with Deltamethrin (Decis) fortnightly) with a yield of 29t/ha. The lowest yields were recorded from outdoor seedlings with no insecticide application (20t/ha).

Tomato: Tanzania

A.P. Maerere, K.P. Sibuga, H. Mtui, M.W. Mwatawala;, M.J. Erbaugh, J. Kovach, M.A. Bennett, M.D. Kleinhenz, D. Doohan, D. Taylor

Dissemination of recommended IPM practices:

The objective of the activity was to demonstrate the effect of IPM practices on tomato insect pests and diseases. Based on farmer evaluation of on-station trials, practices that were selected by farmers for on-farm verification were mulch + pesticide application based on pest scouting. Mulch was applied at 3 different thicknesses: (1) 5 cm; (2) 10 cm and (3) 15 cm. An un-mulched plot was the control. The variety used in the demonstration was called Tanya. The demonstration plots were established at Mlali and Misegese (Msikitini) villages. The mulching materials used were either dry grass (predominatly *Panicum* spp.) or dry rice straw depending on availability. The plots were used to train farmers on the following aspects of tomato production:

- Seed treatment
- Nursery establishment
- Field establishment and fertilizer application
- Scouting for insects and diseases
- Pesticide application

The village extension worker met with the farmers onsite on a designated day, once a week for pest scouting and pesticide application, when needed. Researchers visited demonstration plots and interacted with farmers at least once every two weeks to monitor and evaluate, conduct training, and discuss the development of the crop.

Figure 1: Farmers applying mulch (left); a mulched plot (centre); farmers and researchers in discussion on crop development (right).

Observations/comments made by farmers:

- Application of mulch delayed weed appearance in the field;
- Mulch generally reduced the need to irrigate frequently – compared to a non-mulched nearby plot, the irrigation frequency under mulch was approximately once in two weeks compared to three in the un-mulched plot over the same period of time;
- Mulch generally reduced the weed population – the thicker mulch was most effective thereby reducing drudgery associated with weeding;
- Tomato plants in the mulched plots were much more vigorous than in the un-mulched plots; and
- Mulching reduced incidence of fruit rot, particularly blossom end rot.

Assessment of yield loss due to weeds in tomato and some selected vegetables.

Yield loss assessment, due to weeds, for tomato, sweet pepper, and Chinese cabbage was done in two field trials using a split plot treatment arrangement with vegetable types, as main plots, and weeding regimes as sub plots. Field layout was a randomized complete block design with three replications. Data on growth and yield variables of the vegetables, weed types and weed dry biomass were recorded.

Results showed that weeds where left unchecked, assumed dominance soon after the vegetables were established. Thus, unweeded plots resulted in the highest weed dry matter of approximately 1.5 tons/ha. On the overall, Chinese cabbage and tomato were relatively more competitive against weeds compared to sweet pepper which failed to produce harvestable yield under season-long weed competition. Both grasses and broadleaf weeds were observed. The most dominant weeds were blackjack (*Bidens pilosa*), wondering jew (*Commelina benghalensis*), Mexican fireplant (*Euphorbia heretophylla*), and *Digera muricata.*

Comparing and contrasting gender and contextual influences on tomato production

E. Wairimu Mwangi, M. Erbaugh, K. Sibuga, and M. Waiganjo

The purpose of this study was to compare and contrast gender and contextual influences on tomato production farm-level decision-making and marketing practices, and to use this information to improve IPM program design and delivery. Data from baseline surveys conducted with tomato farmers at IPM CRSP research sites in Kenya and Tanzania in 2006 were used for the analysis and represent two different tomato production contexts. Tomato growers were interviewed using a structured questionnaire resulting in 120 questionnaires, 23 female and 97 male, being completed in Kirinyaga District, Mwea Division, in Kenya; and 100 questionnaires, 33 female and 67 male, completed in Morogoro Region, Tanzania.

Regardless of context, gender influenced access to resources (less land and education) and this influenced production quantity and decision making. The implication is that gender differences need to be incorporated into IPM programs by ensuring female participation and access to training and knowledge transfer opportunities.

Contextual differences predominated, suggesting that "one-size does not fit all" and that planned interventions need to be tailored to specific contexts in which gender relations unfold.

Farmers at both sites reported the prevalent use (16-24 applications per season) of chemical pesticides and males at both sites were more likely to apply the pesticides. Male farmers were more likely to keep records on pesticide usage than female farmers with no difference between contexts, perhaps reflecting more years of education for males.

Farmers indicated that extension agents were relatively minor sources of information indicating that they too may require additional training on horticultural production and IPM.

Male farmers in Morogoro were found to harvest and sell more tomatoes which appear to be related to the amount of land in tomato production.

The study provides evidence that the gender-specific nature of traditional African farming is transitioning. When examining the ratio of crop sold to crop harvested (proportion marketed) no significant gender or contextual differences were found indicating that that higher value marketed crops like tomato may not fit into the traditional male/cash crop, female/food crop dichotomy suggested in the literature.

Horticultural cash crop production suggests an important contextual basis for differentiating the demand/need for IPM programs. Contextual similarities in the production of higher value marketed horticultural crops including female cash crop production and the prevalent use of synthetic pesticides and fertilizers requires that IPM research focus on developing alternative pest and crop management strategies along with training that focuses on pesticide usage and safety.

Tomato: AVRDC/Arusha
Spiderplant (*Cleome gynandra*) as a repellent crop for *Thrips* sp. in Tomato

Marcella Dionisio, Maurice Samzugi, Drissa Silué, Greg Luther

Two trials were conducted from July to October 2008 and from February to May 2009 using the tomato variety Tengeru 97. Each plot was surrounded by one row of spiderplant. Plants were maintained by using standard cultural practices. Three treatments tomato monoculture, tomato intercropped with spiderplant and spiderplant monoculture were compared in a Randomized complete block design experiment with three replications. Hand-made traps (50 x 35 cm) using polyethylene white plastic sheet 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. Thrips were counted in the laboratory on the removed traps using a stereo microscope. ANOVA analysis was carried using COSTAT software.

In second trial no significant differences were shown among the treatments while in the second trial significant differences were shown during day 35. In fact, the mean thrip number was significantly reduced in the tomato/spiderplant intercrop as compared to the tomato monoculture. This finding was confirmed by the lowest number of thrips on the spiderplant monoculture treatment. It can be assumed that spiderplant has the potential to reduce thrip attack as previously shown in the first trial in 2007.

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

Marcella Dionisio, Maurice Samzugi, Drissa Silué, Greg Luther

Experiments were conducted to determine the efficiency of Tanzanian sunhemp (*Crotalaria ochroleuca*) as repellent crop for *Thrips* sp. in tomato culture at AVRDC-RCA in Arusha. Tengeru 97 was used as test tomato variety. Each plot was surrounded by one row of sunhemp. Three treatments (tomato monoculture, tomato intercropped with Tanzanian sunhemp (*Crotalaria ochroleuca*) and Tanzanian sunhemp monoculture) were compared in a randomized complete block design experiment with three replications. Hand-made traps (50 x 35 cm) using polyethylene white plastic sheet with trapping insect glue, OEKOTAK® for the first season and STIKEM® for the second season. Five traps were put in each treatment and replaced every week with new ones. The removed traps were carried to the laboratory for counting the number of thrips using a stereo microscope. Data were compiled and ANOVA analysis carried out using COSTAT software.

Significant differences were shown among the treatments during week no. 4 and 9. In fact, the mean thrips number was highest on crotolaria followed by tomato intercropped with crotolaria and lowest on the tomato monoculture. This tends to believe that crotolaria is a trap crop for thrips (Figure 2). This tendency was confirmed during week 9 where the treatments tomato intercropped with crotolaria and crotolaria monoculture had higher thrips numbers. Thrips numbers were not significantly different during the remaining weeks of the experiment. In trial no. 4, data collected in day 56 confirmed those of week 4 and 9 of trial no. 2. In fact, the thrips number was lowest on tomato monoculture as compared to the tomato/crotolaria and crotolaria monoculture treatments.

Yellow and orange marigold (*Tagetes sp.*) flowers as trap crops for thrips in tomato

Maurice Samzugi, Drissa Silué, Greg Luther

The experiment was conducted at AVRDC-RCA in Arusha from February to May 2009. Tengeru 97 was the tomato variety used. Each plot was surrounded by one row of marigold. Plants were maintained by using standard cultural practices. Three treatments tomato monoculture, tomato intercropped with spiderplant and spiderplant monoculture were compared in a Randomized complete block design experiment with three replications. Hand-made traps (50 x 35 cm) using polyethylene white plastic sheet were made and spread with trapping insect glue OEKOTAK® for the first season and STIKEM® for the second season. Five of them were put in each treatment and replaced every week with new ones. Thrips were counted in the laboratory on the removed traps using a stereo microscope. ANOVA analysis was carried using COSTAT software.

No significant differences were shown among the treatments meaning that both marigold types have a similar effect on attraction of thrips. The orange flower marigold type attracted overall more thrips than the yellow flower type especially at 58 to 100 days of the experiment.

Biocontrol of soilborne diseases using Brassica crops

Marcella Dionisio, Maurice Samzugi, Drissa Silué, Greg Luther

Broccoli (var. Calabrese) and African indigenous crops [Ethiopian mustard (Mbeya green and Mbeya purple), Spiderplant (green and purple stem)] were tested for their bio-fumigation properties against soilborne diseases. On the other hand, four susceptible crops 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 total area was 71 m X 12 m. Each plot measured 3 X 1.5 m. All the plants were grown by using standard cultural practices. The bio-fumigant crops were allowed to grow for 6 weeks after which 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 2: Trap crop in an experimental field

Hot Pepper: Uganda:

J. Karungi, S. Kyamanywa, S. Mukasa, M. Ochwo, P. Agamile, G. Luther, S. Miller and J. Kovach

Dissemination of eco-friendly pest management options

After confirming the results of the on-station trial aimed at developing eco-friendly pest management options including cover cropping, use of a biopesticide (neem), sulphur and prophylactic treatments with a pesticide; a trial was then conducted on-farm as a dissemination strategy. The same design used on-station, i.e., in a split-plot randomized complete block design with three replications was used with the hot pepper + cowpea system vs. a hot pepper monocrop as main effects and 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. At the fruiting stage, a field day was organized and pepper farmers in Sub county and the neighbouring areas were invited.

The farmers expressed their appreciation for the involvement of Makerere University and the IPM CRSP in promoting safe and effective pest management technologies for hot pepper production.

- Farmers preferred cover cropping/intercropping hot pepper with cowpea.
- Farmers used some of the harvested fruits to process the seed for the next season as hot pepper seed is not available on the market.
- Hot pepper viruses remain as the biggest constraint to hot pepper production and this has sometimes led to field abandonment.
- Farmers appealed to the scientists/researchers to help them find solutions for bacterial wilt of tomato, another important commercial crop in the district.

Assessment of the efficacy of reduced spray regimes for control of *H. armigera* in tomato fields

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

An experiment arranged in a randomized complete block design, with three replicates, was being conducted at Makerere University Agricultural Research Institute, Kabanyolo. There were five treatments: No spray, spray throughout, spray at beginning of budding, and spray at the beginning of fruiting.

This study has demonstrated that a range of 6-9 insecticide sprays per season is effective for control of *H. armigera*¸ reducing level of fruit damage by two to three-fold (Figure 3) and increasing the amount of harvestable fruits.

The undergraduate student, Caeser Odong has submitted his special project report on, “Efficacy of spray regimes for the control of tomato fruitworm (*Helicoverpa armigera*) in Uganda.

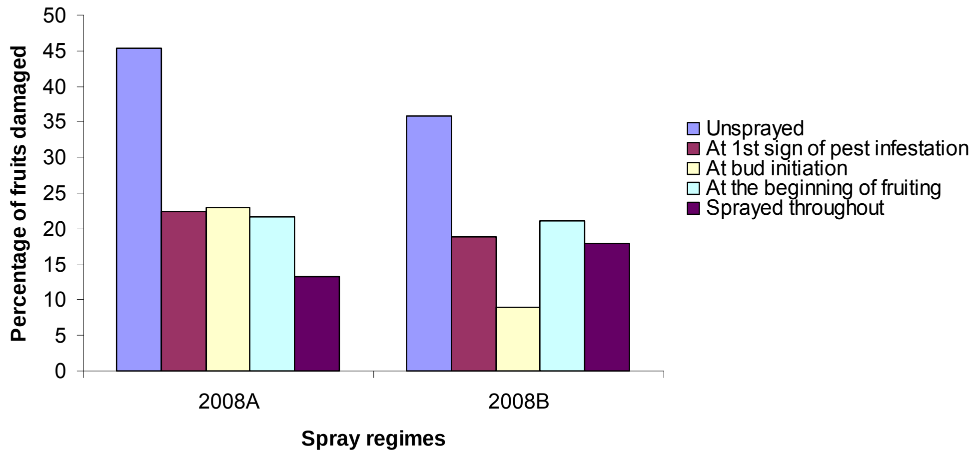


Figure 3: Graph comparing spray regimes by percentage fruits damaged.

Effect of intercropping tomato with maize, sorghum and beans on the population dynamics of *H. armigera* and its natural enemies.

The experiment on the effect of intercropping on *H. armigera* infestation was done for three consecutive seasons. The treatments were: sole tomato (sprayed and unsprayed), and tomato intercropped with each of maize, sorghum and beans. The treatments were in a randomized complete block design with three replications.

There was no marked difference in the incidence and damage of *H. armigera* in intercropped fields compared to the unsprayed control, although the sprayed plot had lower incidence and damage levels.

Six pheromone traps and twelve lures for *H. armigera* were received from India on suggestion of Dr. Muniappan, the Director IPM CRSP. The traps were set up in farmers' fields. Some of the traps captured the pest, confirming the fact that Uganda's species is similar to that in Asia.

Passion fruit: Uganda

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

Optimization of PCR for diagnostic primers designed to detect the virus species tentatively designated to the Ugandan Passiflora potyvirus (UgPV).

Primer reactions were optimized and characterization of the collection of virus isolates in has been accomplished using representative virus isolates.

Thaddeus Kaweesi (Research Assistant-Horticulture Program, NaCRRI) trained in the use of PCR in virus characterization.

Protocol for identification of the UgPV developed.

Evaluation of germplasm for tolerance to passion fruit viruses and other diseases

The trial was established first in the screen house and then taken to an open field at NaCCRI imitating farmers' conditions to study tolerance and incidence levels of various passion fruit types. Randomized block design was used where the field was divided into three blocks and seedlings of various passion fruit types randomly placed in each block. 10 replicates for each fruit type were used. The three passion fruit types under investigation were the hard shelled, purple type and the yellow type.

The most abundant pests observed were white flies, thrips, mites and aphids in decreasing order. Fungal diseas severity was highest on yellow type, mild on purple and not on hard shelled. Plant vigor followed the order yellow >purple> hard shelled

Development of IPM packages for viruses infecting passion fruit in Uganda

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

An experimental trial was established at NaCRRI in October 2008. This trial included virus-clean seedlings of three types of passion fruit: purple (*Passiflora edulis edulis*), yellow (*Passiflora edulis flavicarpa*) and hard shelled (*Passiflora maliformis*) established in a randomized complete block design with 3 replicates. Data were collected for one year on weekly basis from three weeks after transplanting. Data included growth parameters, pest/disease incidence and severity, and yield.

Three types of insects were recorded affecting passion fruit: Mites, thrips and aphids. Viral disease also occurred and damage varied with passion fruit type. Among the aphids affecting passion fruit was *Aphis gossypii* (cotton aphid). This is the first time that viral disease occurrence has been closely linked to aphid transmission in Uganda.

A one-day scientific workshop was organized at NaCRRI that attracted 30 scientists, including the Program leader, Horticulture (NaCRRI), Dr. Peter Sseruwagi. The workshop was opened by the Assistant Regional Coordinator IPM CRSP East Africa, Dr. Jeninah Karungi.

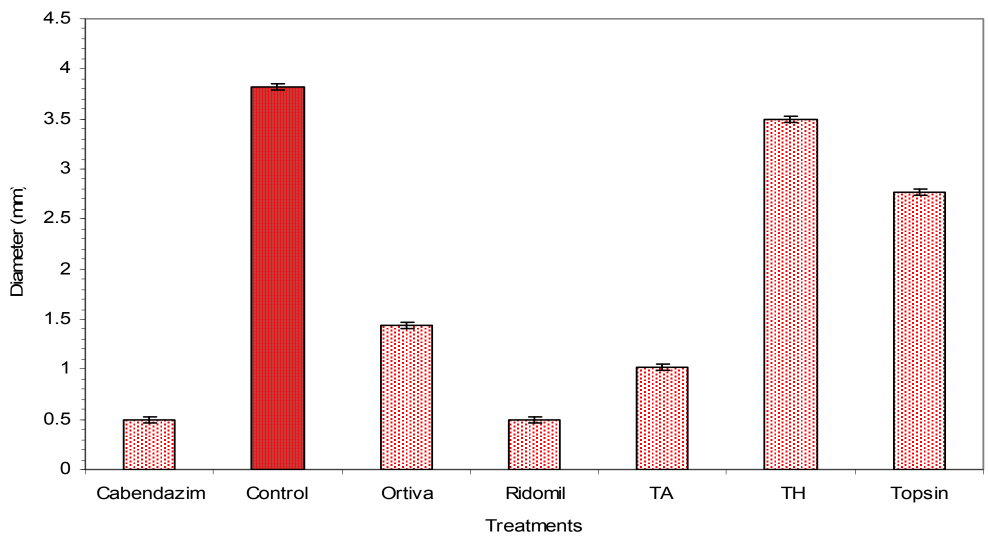
Passion fruit: Kenya

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

Development of IPM strategies for the management of fungal diseases in passion fruit production systems in Kenya

Biocontrol agents (*Trichoderma harzianum* and *T. asperellum)* and fungicides including carbendazim (Rodazim), thiophanate-methyl (Topsin), Azoxystrobin (Ortiva), metalyxl (Ridomil) were separately introduced into potato dextrose agar (PDA) media before pouring onto petri plates. A mycelial plug (5mm) from the periphery of a 10 day old *F. oxysporum* fsp *passiflorae* culture was transferred aseptically to the centre of each PDA plate containing the individual fungicides and biocontrol agents at rates recommended by manufacturers for dilution in water. PDA plates without treatments were used as controls. Each treatment was repeated five times in a completely randomized design. Diameters of fungal colonies were measured at 3, 4, 5, 6, and 7 days after inoculation to the nearest millimeter (mm). The inhibitory activity of fungicide and biocontol agents was determined by calculating the inhibition percentage.

In vitro tests on the effect of fungicides indicated in 1a) on the mycelial growth of *F. oxysporum* fsp. *Passiflorae* revealed that cabendazim and metalaxyl had the most inhibitory effect on mycelial growth on artificial media (PDA) followed by azoxystrobin and lastly topsin (Figure 4). Of the two biocontrol agents, *T. asperellum* inhibited more of the growth of the fungus relative to *T. harzianum*. *Trichoderma asperellum* inhibited more of the growth of the *Fusarium* wilt pathogen relative to ortiva and topsin (Figure 4).



Treatments: Cabendazim, Control, Ortiva, Ridomil, *Trichoderma asperellum* (TA), *T. harzianum* (TH), and Topsin

Figure 4: The effect of selected fungicides and biological control agents on mycelial growth of *F. oxysporum* fsp. *passiflorae* on Potato Dextrose Agar

Evaluation of biocontrol agents and selected fungicides on the management of fusarium wilt

Trials involving the use of biological control agents *Trichoderma harzianum* and *T. asperellum* and 5 chemical fungicides, Bavistin (Carbendazim), Cotaf (Hexaconazole), Ortiva (Azoxystrobin), Topsin (Thiophanate methyl), Ridomil (Metalaxyl) against Fusarium wilt disease caused by *F. oxysporum fsp. passiflorae* on the purple passion fruit were set up in a Complete Randomized Design with 3 replications. The treatments were diluted in water as per the manufacturers recommendations and introduced in soil both before and after introduction of inoculum (10^6 spore concentration of *F. oxysporum* fsp. *passiflorae* per 1ml of water). Data collection on rate of plant growth, number of plants yellowing / wilting, and number of dead plants is ongoing.

Data on trials involving the use of biological control agents *Trichoderma harzianum* and *T. asperellum* and 5 chemical fungicides, Bavistin (Carbendazim), Cotaf (Hexaconazole), Ortiva (Azoxystrobin), Topsin (Thiophanate methyl), Ridomil (Metalaxyl) data collection is ongoing.

Evaluation of biocontrol agents and selected fungicides on the management of dieback disease

The importance of timely pruning coupled with fungicide application using 5 chemical fungicides and biocontrol agents were tried at KARI NARL greenhouses. Purple passion fruit plants infected by dieback were used for these trials. In this demonstration plants affected by dieback pruned and treated with the fungicides and biocontrol agents as per the manufacturer's recommendations. Another 3 plants also affected by the disease were left unpruned and exposed to the same treatments. Controls were left untreated.

Biocontrol agents (*T. asperellum* and *T. harzianum)* have shown positive tendencies in managing this disease. Fungicides including carbendazim (Rodazim) and the bio-control agents (*T asperellum* and *T. harzianum*) are so far showing promising tendencies in the control of this disease. However data collection is ongoing and data analysis will be useful in determination of significant differences amongst treatments.

Evaluation of passion fruit lines for their tolerance to Fusarium wilt, collar rot and brown spot

Virulent strains of *F. oxysporum* fsp. *passiflorae* and *F. solani* were grown on separate plates of carnation leaf agar and spores harvested at 14 days of growth. Ten ml of water with an inoculum concentration level of 10^6 per ml was introduced onto autoclaved 2g corn substrate (2g) and let to grow for ten days at 25º C. The actively growing inoculum (2g corn substrate) was introduced to the sterilised soil of each of the four lines (KPF_{11}, KPF_{12} and KW). The lines were replicated four times. The lines are being monitored for wilt and collar rot symptoms. The lines were also monitored for their tolerance to brown spot under natural infection. The purple passion fruit was used as a control.

Identification of passion fruit viruses in Kenya and to assess the reaction of passion fruit germplasm to these viruses

Twenty six samples previously collected in Uasin Gishu district and stored were characterised for symptoms indicating virus infection including; crinkling of leaves, chlorosis / yellowing and woodiness of fruits prior to DNA extraction using RT PCR analysis for viruses including *Cucumber mosaicvirus* (CMV), *cowpea aphid borne mosaic virus* (CABMV) and *Passion fruit woodiness Virus* (PWD) as follows: **a) Use of housekeeping genes** (actin and rubisco primers) RNA extraction for 48 samples was done using Qiagen R Neasy plant mini kit. First-strand cDNA synthesis using Thermoscript Reverse Transcriptase and using actin and rubisco primers has been carried out on 12 samples to ascertain the presence of good quality RNA. 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, CABMV and PWD: Symptomatic and asymptomatic plants were indexed for presence of CMV, CABMV and PWD using RT-PCR protocols using primers specific to the viruses. Following PCR amplification of the cDNA, the expected products were observed on 1% agarose gel.

Biological characterization of isolates
Indicator plant species *Nicotiana benthamiana*, *Chenopodium quinoa* and *Datura stramonium* were planted in the greenhouse and will be sap inoculated with identified virus isolates and monitored weekly for symptom development. Serology will be used to confirm virus presence.

Evaluation of the reaction of passion fruit germplasm to viruses: Passion fruit lines including KPF_{11}, KPF_{12} and KW have been planted in a greenhouse in NARL and will be investigated for their tolerance to viruses. The purple passion fruit will be used as the control.

Tentative results indicate that over 50% of the samples from Uasin Gishu have strains of *Cucumber mosaic virus*. Less than 10% of the samples were observed to be positive for *Cowpea aphid borne virus* and *Passion fruit woodiness virus*. However the bands were not very clear for the later two viruses and repeat analysis are underway to standardize protocols and confirm these results.

Screening *Passiflora* Species
Robert Gesimba and Dan Struve

In an effort to develop a drought and *Fusarium* wilt resistant *Passiflora* rootstock, a series of experiments were conducted at The Ohio State University and Egerton University in Kenya to study vegetative propagation, compatibility, drought tolerance and *Fusarium* wilt resistance in *Passiflora* species; to determine the *Fusarium oxysporum* ecotypes present in Kenya and to identify an integrated control method for *Fusarium* wilt.

The *P. edulis f. flavicarpa* plants currently being used by farmers may not be true-to-type and hence susceptible; *Passiflora subresa, P. incarnata* and *P. caerulea* can be improved for use as rootstock alternatives for purple passion fruit. For *Fusarium* resistant *P. subresa* breeding should focus on improving compatibility and drought tolerance. For drought tolerant *P. incarnate* improvement should focus on compatibility and *Fusarium* wilt resistance. Since *P. caerulea* is compatible with *P. edulis* and is drought tolerant improvement should focus on *Fusarium* wilt resistance. ICIS-pot irrigated passion fruits had longer vines in the field. Thus, the use of ICIS-pot and ICIS-mulch together with either and Rodazim 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. Contrary to growers claims, *Passiflora edulis f. flavicarpa* is resistant to Fusarium wilt.

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

Analysis of cyanogenic glycosides in the aerial portions of eight *Passiflora* species
Robert Gesimba and Dan Struve

There are four structural types of cyanohydrin glycoside compounds in the Passiflora genera: cyanohydrins, cyanohydrins with a rare sugar residue, a sulfate group, or additional oxygenation of the cyclopentene ring, linamarin, prunasin. The type of cyanohydrin glycoside may be involved with graft incompatibility. However, detection, isolation and/or characterization of these compounds are costly. It was hypothesized that the amount of cyanogenic glycoside produced by the rootstock may predict scion graft compatibility with *Passifloria edulis*. *P. edulis* has a very low level of cyanogenic glycoside. To test the hypothesis that the amount of cyanogenic glycoside in the rootstock (regardless of structural type) is related to graft compatibility, six species were obtained and the amount of cyanogenic glycoside in the stem tissue was analyzed.

The µmoles amygdalin equivalents per gram fresh weight is given in Table 5. For the limited number of comparisons available, those species with the lowest concentration of cyanogenic glycosides (µmols amygdalin equivalents per g fresh weight) had the greatest grafting success and, with the exception of *P. bifloria*, the greatest scion growth rate (Table 6). There appeared to be no relationship between the type of cyanohydrin glycoside, grafting success and scion growth rate. Only *P. edulis* had type IV cyanohydrin glycoside.

Table 5: Colorimetric assay of cyanogenic glycoside content in the aerial portions of eight *Passiflora* spp. and spinach (*Spinacea oleraceae*)

Sample		Mean ± S.E. (μmols amygdalin equivalents/g fresh weight)
Spinach[z]		-0.07 ± 0.00[y]
Passiflora spp.		
	P. altinis	2.32 ± 0.10
	P. bifloria	0.27 ± 0.03
	P. caerulea	1.52 ± 0.12
	P. citrine	2.18 ± 0.03
	P. edulis	0.07 ± 0.06
	P. incarnata	1.58 ± 0.02
	P. suberosa	7.23 ± 0.28
	P. yukatanensis	1.33 ± 0.19

[z]Spinach analyzed as a control.
[y]Value is essentially zero.

Table 6: Subgenera, grafting success, μmols amygdalin equivalents/g fresh weight, scion growth rate after grafting and type of cyanogenic glycoside in eight *Passiflora* species

Species	subgenera	grafting success (%)	μmols amygdalin equivalents/g fresh weight	Scion dry weight accumulation (g/day)	Type of cyanohydrin glycoside(s)
P. altinis		not done	2.32		
P. bifloria	Decaloba	66	1.27	0.03	II
P. caerulea	Passifloria	89	1.52	0.77	II
P. citrine	Decaloba	66	2.18	0.02	II
P. edulis	Passifloria	100	0.007	0.81	IV
P. incarnate	Passifloria	100	1.58	0.52	II
P. suberosa	Decaloba	not done	7.23		I, II
P. yukatanesis	Decaloba	100	1.33	0.03	unknown

There needs to be additional testing of different species with in the *Passifloria* subgenera to determine the relationship between the amount of cyanogenic glycoside in the foliage, grafting success and scion growth rate.

Based on the equal grafting success between *P. edulis* scion and *P. bifloria* and *P. citrine* rootstocks (both are members of the *Decaloba* subgenera) subgenera seems to have the greater affect on scion growth rate than does the cyanogenic glycoside concentration; they had similar grafting success (66%), and similar scion dry rate accumulation (0.02 and 0.03 g per day), but the cyanogenic glycoside concentration was almost twice as great in *P. citrine* as in *P. bifloria*.

Further studies need to be done due to the limited number of species sampled. However, the technique may represent a rapid root stock screening method where graft compatibility is associated with low cyanogenetic glycoside content of the rootstock foliage. The cyanogenetic glycoside content of the rootstock foliage maybe used to screen within species variation in rootstock compatibility.

Banana: Uganda

Use of PCR for monitoring progressive movement of *Xanthomonas campestris* pv. *musacearum* in apparently healthy banana suckers

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

With the onset of the deadly banana bacterial wilt disease caused by *Xanthomonas campestris* pv. *musacearum,* many studies have been carried out to gather information for use in designing management approaches for the disease. Among the studies done were the development of diagnostic tools for the causal bacteria. Specific primers were developed and successfully used in identifying the causal bacteria. Subsequently, we used the primers to monitor the progressive movement of *Xanthomonas campestris* pv. *musacearum* in apparently healthy banana suckers, and established that (i) *Xcm* migrates fairly quickly from top to bottom of the plant before any observable symptoms develop, (ii) by the time banana wilt symptoms are recognized, *Xcm* has moved from the top to the base of the plant and in most cases into the suckers, although it remains latent, making such suckers dissemination vehicles for the disease. As a result we recommended that plants exhibiting xanthomonas wilt symptoms be destroyed along with their suckers, however healthy these suckers may appear. It was however necessary that this information be drafted into a Research Guide for technical personnel outlining procedures of detecting *Xcm in-planta*. To design a research guide on the detection of *Xcm* in banana plants using PCR. This guide with the entire procedure from field sampling, through DNA extraction to carrying our PCR is meant to be one of the dissemination strategies for this technology.

Coffee: Uganda

P. Kucel, J.P. Egonyu and R. Wekono (NaCRRI); S. Kyamanywa, J. Bonabana J. Kovach, D. Taylor, M. Erbaugh.

Three field experiments and 2 bio-assay studies were designed to test various IPM options for control of the key insect pests identified in the previous phase of IPM CRSP. Use of soil applied pesticide (Furadan), mineral (calcium ammonium nitrate) fertilizer; organic manure (cow dung) and bean intercrop were evaluated for control of coffee root mealy bugs. Stem wrapping using banana fibers, stem smoothening and stem banding using chlorpyrifos were tested for control of stem borers. A third field trial sought to establish the economic injury levels for the key pests of Arabica in the Mt. Elgon area. Foliar spray using Fenitrothion and soil application of Dursban singly and in combination (foliar and soil application) were carried out to vary the incidence of the pests. The laboratory bio-assay studies were designed to lay a basis for detailed bio-control studies of antestia bugs and coffee berry borer.

All the IPM treatments for controlling root mealy bugs had significantly lower incidence of the pest than the control, except intercropping with beans (Table7).

Stem smoothening and banding did not significantly reduce incidence of stem borers compared to the control. Interestingly, stem wrapping had a significantly higher incidence of stem borers than the control. Besides, stem wrapping was observed to attract termites to destroy the coffee.
During the study period on EIL experiment, the mean incidences of leaf miners, lace bugs and antestia bugs were only 3.7, 0.5 and 0.002%, respectively. Canopy mealy bugs and scales also had low severities of 1.5 and 1.4, respectively on a scale of 1 to 5. The five pests were therefore considered minor at this time.

In the EIL experiment, soil applied insecticide (Fenitrothion) significantly reduced root mealy bugs incidence while the foliar applied counterpart (Dursban) reduced stem borer incidence significantly. Surprisingly, the combination of the two insecticides did not significantly reduce the incidences of either pest.

Coffee bean samples were collected and prepared for quality analysis. The journal papers for these findings are being drafted and will be completed after yield data for the on-going main harvesting season, which runs up to November, is collected.

A socioeconomic survey was carried out to determine the economic benefits of the IPM packages. This data will form part of the publications.

One hundred and seventy four farmers including 33 females were trained in Mbale and Sironko districts on different aspects of Arabica coffee production. These included:

- Aspects of general management of Arabica coffee
- Integrated pest management in Arabica coffee
- Safety measures in pesticides use
- Record keeping and coffee production as a business

Table 7: Effect of IPM treatments on incidences of Arabica coffee pests in Mt. Elgon area of Eastern Uganda

Root mealybug IPM experiment		**Stem borer IPM experiment**		**Root mealybugs and Stem borer EIL experiment**		
Treatment	Incidence (%)	Treatment	Incidence (%)	Treatment	Incidence of Root mealy-bugs (%)	Incidence of Stem borers (%)
Furadan	14	Stem wrapping	36.7	Fenitrothion	44.2	4.8
CAN	25.3	Stem smoothening	29.5	Dursban	22.8	8.6
Animal manure	22.8	Stem banding	31.2	Fenitrothion + Dursban	39.4	10
Bean intercrop	32.4	Control	30	Control	46.7	11.3
Control	35.7					
$LSD_{0.05}$	3.5	$LSD_{0.05}$	4.6	$LSD_{0.05}$	7	4.4

Development of Arabica coffee production budgets in Mt. Elgon region

A pre-designed data sheet was administered to twelve randomly selected Arabica coffee farmers in the three Mt. Elgon region districts of Manafwa, Sironko and Mbale. Cost information collected included input costs (chemicals, farm implements, fertilizer, manure etc), labor costs (for weeding, de-suckering, pruning, chemical application etc.) and coffee processing costs. In addition, volumes of coffee output and farm-gate prices were obtained. The total costs that vary were computed by combining input, labor and processing costs across all farms. Gross field benefits were obtained by factoring prices with output volumes. Net benefits were obtained according to the formula: NB = GFB – TVC; where:

NB = Net Benefits
GFB = Gross Field Benefits
TVC = Total Variable Costs

Net benefits were compared to total variable costs to obtain profitability across farms. The comparison was made on a per-acre basis.

Coffee farms ranged from 0.5 to 2.5acres while average farm gate price was Shs 2,359/kg and average output was 289kg. Table 1 shows the per-acre variable costs and gross field benefits of the farms. Total variable costs were between 73,750 (farmer 4) and 418,000shs/acre (farmer 7). In addition, farms 7 and 5 had the highest gross field benefits/acre.

Table 8: Comparison of net benefits to total variable costs across farms

Farms	Area (Acres)	TVC/acre ’000shs	GFB/acre ’000shs	NB/acre ’000shs	(NB/TVC) per acre
FM 1	0.50	258.0	360.0	102.0	0.79
FM 2	2.50	196.4	658.0	461.6	0.94
FM 3	1.00	84.8	152.5	67.7	0.80
FM 4	2.00	73.8	125.0	51.3	0.35
FM 5	1.75	300.6	1585.4	1284.8	2.44
FM 6	1.00	137.3	792.0	654.7	4.77
FM 7	0.50	418.0	921.6	503.6	2.41
FM 8	1.50	210.7	216.7	6.0	0.02
FM 9	1.50	292.7	326.4	33.7	0.08
FM 10	1.00	90.0	487.5	397.5	4.42
FM 11	1.50	131.5	340.0	208.5	1.06
FM 12	0.50	306.0	322.0	16.0	0.10

The last column of Table 8 shows a comparison of net benefits to total variable costs across farms. Farm 6 has the highest profitability. For every one shilling investment in production, the farmer obtains over 3 shillings extra (4.77-1=3.77). Farmer 12 was the least profitable with a benefit-cost ratio of 0.10. The correlation between the ratio of net benefits to total variable costs and acreage is weak (Pearson corr. coeff. is -0.201) indicating that profits may be scale neutral on these coffee farms and suggesting perhaps the importance of other factors such as labor and purchased inputs.

Figure 5 below shows the share of various inputs in coffee production. In general, labor accounts for the highest production cost. Sixty percent of the total variable costs can be attributed to labor while purchased supplies contribute 30%. Further cost analysis indicates that the most profitable farms are least-labor intensive – they spend more on purchased inputs than on physical labor (for instance preferring to use pesticides instead of manually removing diseased plants).

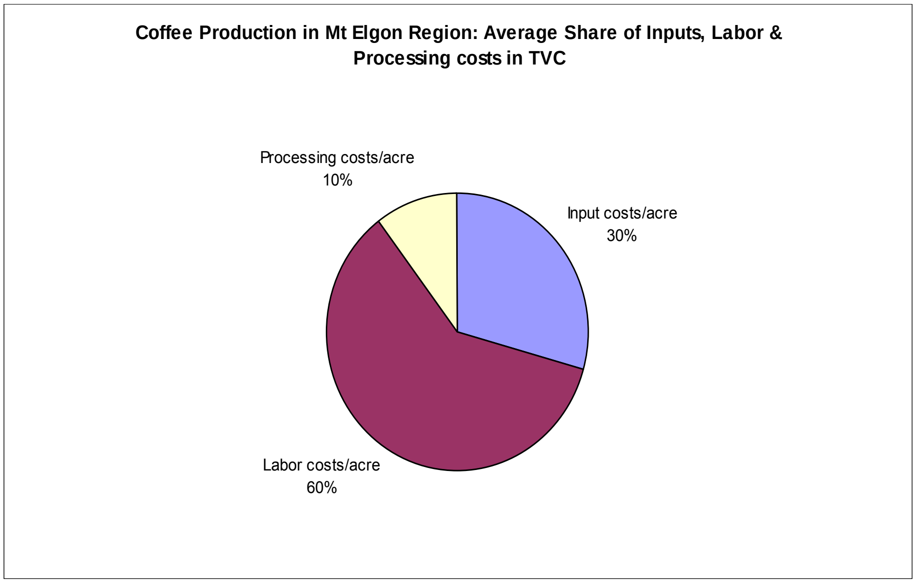


Figure 5: Shares of various inputs in coffee production

Forty-two percent of interviewed farms used chemicals (pesticides, fungicides and insecticides) on the farms with costs ranging from 10,286shs/acre to 20,000shs/acre with some farmers reporting up to 3 applications a year. The share of the direct costs of chemical input and application was 6.8% indicating the potential contribution of IPM towards minimizing production costs.

Farm profitability was not related with farm size. This suggests that other factors other than the scale of operation may be important in increasing Arabica coffee farm profitability in Mt. Elgon region.

Overall, coffee production in the region was profitable. All farms exhibited positive net benefits although the value of the margins varied widely.

The three most profitable coffee farms had the least labor costs, suggesting that either farmers' use of chemicals enhances their profitability or high profitability enables farms to purchase chemicals and save on labor charges. There is need to investigate the direction of this relationship and to include indirect costs of chemical use which may reveal a negative relationship between chemical use and benefits.

Achievements:

- Coffee farmers trained on record keeping of an important internationally traded crop.

- One hundred and seventy-four farmers including 33 women trained on coffee production as a business
- Coffee production budgets for 12 randomly sampled farmers developed.

Tanzania

Spatial distribution and temporal variations in abundance of white coffee stem borer (WCSB), antestia bug and coffee berry borer (CBB).

Magina, F. L.

Spatial distribution and temporal variations in abundance of white coffee stem borer (WCSB), antestia bug and coffee berry borer (CBB), were investigated between September 2007 and August 2008 in medium altitude (Lyamungo = 1200 – 1600 masl) and high altitude (Kilema =1600 – 2100 masl) areas in Kilimanjaro region. A multistage random sampling method was used to select farms in two locations where in each location, one ward was selected and within each ward three villages were chosen, and in each village fifteen farms were randomly selected for the study. In each farm, nine trees were selected to make a total sample size of 810 trees. Insects were counted every month to establish the population dynamics.

WCSB was dominant in both high and medium altitudes while antestia bugs were dominant in medium altitude and less dominant in high altitude. CBB was dominant in the medium altitude and absent in the high altitude. High populations of antestia bug and CBB were recorded during the short and long rains during flowering and fruit development. WCSB increased gradually during short and long rains. WCSB was more prevalent in the sparse shade while antestia bug and CBB were more prevalent in dense shade (Table 9). Since WCSB was abundant in all locations and caused the most damage, more focus should be directed to the management of this pest.

Table 9: Mean numbers of insect pests at Lyamungo and Kilema in farms with sparse and dense shade

Location	Dense shade			Sparse shade		
	WCSB	Antestia bugs	CBB	WCSB	Antestia bugs	CBB
Lyamungo	10.552b	9.036a	2.975a	20.655a	4.544b	2.550a
Kilema	17.788b	1.228a	N/A	23.475a	0.255b	N/A
Total	28.340	10.254	2.975	54.120	4.799	2.550

Means in a column followed with the same letter are not significantly different ($P \leq 0.05$). Means separations are compared within the locations.

Implement training on safe use of pesticides and IPM technologies for extension agents and farmers.

Training was conducted for farmers groups with botanical gardens. A total of 97 farmers were trained in Uswaa, Mrimbo, Uuwo and Mawanjeni villages. A total of 109 (81 males and 28 females) farmers and extension officers were trained and provided with the leaflets and posters.

12,000 leaflets and 1000 posters were produced and used for training. They were on safe handling of pesticides, pest identification, use of botanicals and IPM approaches to pest management.

Tospoviruses in Vegetable Cropping Systems

M. K. N. Ochwo-Ssemakula, C. Ssemwogerere, C. Muwanga, Naidu Rayapati.

A diagnostic survey was done in four Sub Counties in two districts in Central Uganda i.e., Wakiso (Busukuma and Gombe) and Mpigi (Mpenja and Buwama). In each sub-county, 10 farmers were selected, and of these, 5 were tomato farmers and 5 pepper farmers. Data was collected at 3 growth stages for tomato (vegetative; flowering; & 50% ripening) and for at only one stage of pepper. Thrips were counted and recorded on 5 randomly selected plants. Some of the thrips were collected and preserved in 60% ethanol for identification in the laboratory. Five species of thrips were identified using LUCID keys and morphological keys by Palmer, including:

- *Frankliniella occidentalis*
- *Thrips tabaci*
- *Frankliniella schultzei*
- *Scirtothrips dorsalis*
- *Thrips palmi*

Thrips samples were sent to Washington State University for confirmation of identity. Cropping systems significantly affected thrips occurrence with more occurring in intercropped systems compared to monocrops. Pesticides regimes also affected the occurrence of thrips.

Establishment of tospoviruses in vegetable cropping systems in Uganda

M. Ochwo-Ssemakula and S. Kyamanywa, P. Seruwagi, M. Otim, N. Rayapati and M. Erbaugh.

A survey was conducted for the growing seasons of 2008 and 2009 in two major production areas: Mpigi District and Wakiso District. In each district ten farmers' fields were randomly selected, five involved in tomato production and five in pepper production. Each tomato field was sampled at the vegetative, flowering and 50% ripening stages respectively. Pepper sampling was done only at the flowering stage. The stratified random sampling technique was used for both crops. Data were collected on thrips occurrence by taking counts of thrips found on the underside of the three top most expanded leaflets and one flower per plant in tomato and five flowers per plant in pepper. Thrips were mounted on slides and identified using the dichotomous key and the Lucid key software.

Tospovirus survey: A survey was conducted as for the thrips collection. Data were taken on various management practices as well as disease incidence and severity. Samples with typical symptoms of viral disease were collected and analyzed using immunostrips for two known tospoviruses: *Tomato spotted wilt virus* (TSWV) and *Impatiens necrotic spot virus* (INSV). Virus positive samples were inoculated to two indicator plant species: cowpea and *Nicotiana glutinosa*.

About 100 thrips samples were collected. Among these, six species were identified: *Ceratothrips ericae* (heather thrips), *Frankliniella occidentalis* (western flower thrips), *Frankliniella schultzei* (cotton bud thrips), *Megalurothrips sjostedti* (bean flower thrips), *Scirtothrips dorsalis* (chilli thrips) and *Thrips tabaci* (onion thrips). Onion thrips were the most prominent species on tomato, while western flower thrips and chilli thrips were equally occurring on pepper.

Viral disease occurred more on tomato than pepper. Patterns of disease occurrence were related to occurrence of thrips in infected areas. Viruses with serological relationship to TSWV and INSV were detected among field samples. Inoculation yielded symptoms similar to those reported for the two virus species.

Management practices were found to influence occurrence and severity of infestation of thrips as well as viral disease. These practices include: cropping system, pesticide type and application regime. Data is currently being analyzed.

About 180 thrips samples were sent to Washington State University, USA for further identification. *Mr. Charles Ssemwogerere* and *Mr. Chris Muwanika*, Undergraduate students in the Bachelor of Science in Agriculture degree program of Makerere University was trained on various aspects of research methodology, disease sample processing, use of biotechnology tools in virus detection, insect sample processing and preservation; and insect taxonomy.

Enhancing diagnostic capacity in the IPDN Regional Diagnostic hub laboratory

In order to position itself to handle diagnostic demands from the East African region, the IPDN hub laboratory at the Kenya Agricultural Research Institute (KARI) conducted a two-month internal training course (between January and March 2009) for its staff (mainly the scientists/diagnosticians, technologists and other support staff). The aspects covered included selected topics relevant to pathological analysis in bacteriology, mycology, virology and nematology. The facilitators were the institute's research scientists who displayed a big capacity and resourcefulness. Certificates of achievement were issued after testing and evaluation of participants during the course (attached sample). This created a strong sense of teamwork and enthusiasm to carry out plant disease diagnostics processes. Efficiency in service delivery has since been witnessed and customer satisfaction improved greatly.

IPM CRSP/KARI Co-PI Miriam Otipa discusses plant diseases with Secretary of State Clinton

Interactions have continued with representatives from institutions participating in the IPDN project in eastern Africa, with the result of more diseased samples being received from Kenya (hub laboratory country) for diagnosis.

Development of standard operating protocols for selected pests/diseases

Draft SOPs on banana xanthomonas wilt, banana bunchy top disease, bean root rots, fruit flies and fusarium wilt of bananas have been developed. This has involved an interactive process whereby teams formed during the plant diagnostics workshop held in Makerere University, Kampala, Uganda (attached table) have used agreed templates to reflect the name of pest/problem to be diagnosed, background (significance of the problem, brief literature review, symptoms, etc), protocols on sample collection, processing and despatch (safe submission), sample receipt and examination, sample storage (in preparation for analysis), screening and confirmation (authority), and relevant annexes.

The process culminated with a workshop was in June 2009 at the Kenya Agricultural Research Institute (KARI), Nairobi, Kenya to revise and refine the draft SOPs that were initiated during the last project year. The workshop process involved the use of relevant materials in form of hard copies and/or electronic versions of published and unpublished material in books, journals, conference proceedings, online literature searches, etc. After incorporating the suggestions agreed during the refinement workshop, group leaders have now submitted the refined documents for reading and further editing. An additional SOP has also been drafted for gray leaf spot disease of maize.

Enhancement of RP/EA website portal: This portal was created and is maintained by Dr. Dan Taylor, VT.

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

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 listserve of the lead researchers in each country and in the U.S. as well as listserve of other researchers at the sites and other parties interested in the regional project.

Socioeconomic baseline studies were completed for tomato in Kenya and Tanzania and coffee in Uganda and Tanzania.

Biological monitoring activities were completed with tomato in all three countries, coffee in Uganda and Tanzania, and disease incidence surveys of passion fruit conducted in Kenya and Tanzania.

Three students completed or are continuing graduate work at various institutions. These are Miriam Otipa pursuing a PhD at the Jomo Kenyata University of Agriculture and Technology; Alex Nduati Muchina. MSc Student at Nairobi University; and Fred Magina who completed his thesis and submitted it for examination at SUA.

Modular IPM training components assembled by Drs. Kovach and Erbaugh were used for farmer/extension agent training at KARI/Thika.

Implemented the Pesticide Safety and Usage Program with KARI at Kenyan research site at Mwea from 14-16 October, 2008. Twenty three (15M, 8F) tomato farmers and extension workers were trained.

West African Regional Consortium of IPM Excellence

Donald E. Mullins, Virginia Tech

Development of an online whitefly monitoring system

Extensive sampling was carried out in time and space to understand the dynamics of whitefly populations in vegetable cropping systems. Geographically distinct cropping areas were identified at Gorom, Mboro, and Kolda in Senegal and at Baguineda and Kati in Mali. At each of the selected cropping areas a study site of ≈100 km^2 (10 km ×10 km) was identified for sampling SPW populations. Within each study site 30–50 sampling locations were selected and geographically referenced with a GPS. Sampling of immature SPW (number /cm^2 leaf) was conducted on crops and weeds at each location every14–30 days. Ancillary data on each sampling location (e.g., stage of crop, size of the field, presence of weeds and WF on weeds, pesticide use, etc.) were also recorded. The spatial data collected on immature whiteflies in crop fields showed that overall whitefly population levels (mean ± SE immature per cm^2) during the 2007–2009 cropping seasons at Kolda (2.77 ± 0.17) and Mboro (2.73 ± 0.08) were similar and higher than at Gorom (2.47 ± 0.07). Immature whitefly densities were much lower than on weeds than on crops. In general, whitefly densities on both crops and weeds are lower at the Mali sites compared with any of the cropping regions in Senegal. Mean (± SE) density of immature whiteflies on crops at Kati and Beguineda were 0.26 (± 0.07) and 0.63 (± 0.17), respectively.

Several aspects of whitefly dynamics in two neighboring countries within the W. Africa region are worth noting. First, whitefly activity appears to be concentrated during December to March in Mali, suggesting that it is during this period that management should be focused. Second, in Senegal, whitefly abundance is not only higher than in Mali but is also relatively constant throughout most of the year; in Mali, whitefly numbers are extremely low during certain months of the year. The reason for the differences may be due to a whitefly host-free period, which has been implemented in Mali at Baguineda during July–August, and is being implemented at Kati. Analysis of the spatial data also suggests that the abundance and persistence of whitefly populations is associated with the presence of specific crops in the systems, for example, cotton at Kolda and tomatoes at Baguineda. Differences in the dynamics of the whitefly between Senegal and Mali suggest that IPM programs need to be location-specific because a program developed for whiteflies in one country may not be suitable as is for another country.

It is thought that the insect we refer to as *Bemisia tabaci* is a species complex consisting of 13 or more biotypes and two extant species, *B. tabaci* and *B. argentifolii*. The biotypes are known to vary in their biology, dynamics, host ranges, and their ability for virus transmission. As such, it is important for successful pest management to identify the biotype(s) present in the cropping system. Samples of immature and adult whiteflies from the selected cropping areas in Senegal and Mali were collected and sent to Dr. Judy Brown (University of Arizona) for identification using molecular techniques.

Spatial data on whitefly populations in cropping systems in Senegal and Mali have been collected. Preliminary analysis of these data indicates that there is a strong spatial correlation between whitefly population densities and the occurrence of specific crops. The development and analysis of GIS of the spatial whitefly data and land cover information is ongoing and is expected to provide a better understanding of the crop-pest relationships within the WA region.

Mr. Kemo Badji and Mr. Djibril Badiane are graduate students in the program. Kemo's research topic is population dynamics of the whitefly Bemesia tabaci in vegetable production systems in Senegal. Djibril will be studying the ecology of whitefly's natural enemies in vegetables in Senegal.

Impact analysis on tomato virus management in Baguineda, Mali

The study was focused on IPM strategies designed to control white fly-transmitted viruses on tomato through the application of a host-free period (HFP) technique and the use of virus- tolerant tomato seeds. The surveys consisted of collecting baseline data to assess the potential economic impact of the IPM strategies including improved and disease tolerant tomato seeds on small-scale producers' livelihoods. Activities developed and implemented included training on impact assessment and survey tools, survey implementation and relevant data collection, data entry and analysis.

Impact assessment training workshops were held in Mali and Senegal for national agricultural research and extension systems staff. The survey instruments included a set of three different types of questionnaires for interviewing stakeholders involved in the IPM program such as tomato producers, scientists and industrial experts involved in tomato processing. Data were collected through interviews by fellow scientists. The producers' questionnaire included information such as household characteristics, producer's perceptions and awareness of insects and virus attacks and losses to tomato, producer's knowledge and strategies for pest control factors affecting the adoption of the host-free period and of virus-tolerant tomato production management.

In Mali, data collection was carried-out in two major tomato production areas: Baguineda, where the IPM activities (host-free period and improved tomato varieties) were intensively developed, and Kati, where the IPM program is not yet implemented. Baguineda is located south-east of Bamako, while Kati is to the north-east. The between them is about 60 miles. Both zones are located in the same region (Koulikoro) and have similar production systems. Tomato production is constrained by the *Tomato yellow leaf curl viruses* (TYLCV) in both areas. In Senegal, the surveys were conducted in the Niayes zone where tomato is mostly produced. The Niayes zone includes the main urban areas of Dakar, Thies, Louga, and Saint Louis. The host-free period is not yet developed in this area. Producers use nets in the nurseries as a technique to control virus infestation.

A sample of 600 tomato producers, 300 from each country, was randomly selected. The sample size for each selected area is based on the population size of the survey area. The sample size for each zone was computed using the standard sampling coefficient (K= 300/total size of the population). The proportion of male and female producers in each zone was also taken into consideration.

Data were collected from June to end-July 2009. Three sets of questionnaires were developed and include producers' questionnaire, scientist's questionnaire and industrial expert's questionnaire. Scientists and tomato industrial experts were asked about their opinions and chance of technical success and estimated changes in costs of inputs and associated yields if technologies are adopted by producers, the time lags related to research and output, and the regulatory mechanisms. Industrial expert surveys were conducted in Saint Louis (Senegal) with the representatives of tomato canneries. Surveys in Mali have been completed and the data are being processed. In Senegal, data collection has been completed.

Producers in both countries are aware of the existence of tomato viruses and its effects on production. More than 75% of producers in Mali are aware of the HFP strategies and its effectiveness on controlling white flies' population. More than 50% of the producers in Mali (or all the producers at Bagumeda) use the HFP. In Senegal, producers are not aware of the HFP strategies but some of them use nets for the nurseries instead. Almost 9% of the producers use this technique to control white flies. Producers revealed that tomato land area, along with production has decreased because of the virus' effect. Average tomato production area was 0.77 ha before the appearance of viruses. This has decreased to 0.25ha (or a 68% drop). The corresponding decrease in production is estimated at 40% in Mali (interim results). After adopting the HFP strategies, production has increased by 20%. In Senegal, the land area and production decreases are estimated at 28% and 66%, respectively. These could change significantly after considering the entire data from Senegal.

Gender, Participatory Research, and Technology Transfer

A gender workshop was conducted June 15-18, 2009 sponsored by the WA IPM CRSP and hosted by the Office of the Irrigated Perimeter of Baguinéda (OPIB) in Mali. It included the participation of 30 researchers, extension agents, and representatives from institutions in West Africa (Benin, Burkina Faso, Senegal, and Mali) that partner with the IPM CRSP. Participants were trained in three areas: gender awareness, gender analysis, and participative methodologies. The participants presented IPM no-host period technology and also carried out research with 298 farmers.

Collaboration with Global Theme Programs

Efforts were made to enhance the plant pest diagnostic capabilities in West Africa. This included co-sponsoring of IPDN workshop and the purchase of laboratory equipment to support a new plant disease diagnostic laboratory at IER Sotuba.

A plant pest diagnostic workshop of the West African IPDN was held in Bamako, Mali, 16-20th February 2009 at the Regional Research Center of Sotuba. Thirty four scientists and extension agents from 9 WA countries, and the African Union Pesticide Committee (AU-IAPSC) were invited to attend the workshop. Number of participants per countries were Benin (2), Burkina Faso (1); Gambia (1), Niger (1), Mali (15), Ghana (4), Senegal (5), Togo (1), and AU-IAPSC (1). The participants were trained in plant disease and insect pest diagnostics. The program featured the use of traditional and molecular biological tools to identify disease caused by viruses, bacteria and fungi were explained and demonstrated.

Influence of agroecosystem biodiversity on virus levels

Surveying of weeds for whitefly around vegetable crops continues in Mali. Nineteen weed species have been identified as common in the fields surveyed. Of these, whitefly have been observed on seven species. Results support our hypothesis that there is a limited spectrum of weeds adapted to co-occur in vegetable fields and that only a specific subset of these serve as routine hosts of whitefly. This data is central to future experiments that will focus effort on understanding whitefly interactions with specific weed species.

Collection of whitefly and weed samples for testing

A large number of weeds have been sampled and assayed for the presence of Gemini virus. None of these tested to date have been positive for the virus, suggesting that weeds suspected of serving as reservoirs of the virus may not be central to its persistence in the agroecosystem.

Djibril Badiane is a Ph.D. student at the University of Dakar, Thies, Senegal with a focus on methods of weed identification, whitefly biology and virus detection.

Assessment crops that serve as refugia for the potato tuber moth (PTM)

The biology of the potato tuber moth was investigated in 2007 by the Senegalese team lead by Kemo Badji. The adult moths mate 3-6 hours following emergence. Eggs are laid on potato tubers. The larvae hatch out, burrow into potato tubers, where they create feeding tunnels. The duration of the entire life history, from egg deposition to adult emergence, under laboratory conditions takes from 24 to 33 days. PTM was observed to attack other crops apart from potato. The crops infested by the PTM include tomatoes and egg plants, and they serve as refugia for the moth. All the phenological stages of these crops are attacked by PTM.

Screening potatoes for resistance to bacterial wilt

Five varieties of potatoes were tested in soil infested with bactrial wilt at the Sotuba station (Table 1). The varieties used are: Spunta (least susceptible), Mondial (very susceptible), Claustar (moderately susceptible) Lisetta and a table potato as the control (source local market). The seeds used were whole tubers. The experimental design was a randomized complete block with 5 replicates. Each block consisted of 5 plots. The size of each plot was 4 m^2, with 2 lines on a spacing of 0.4 m X 0.5 m. The experimental plants were planted in a nursery in January 2009, and then transplanted in the field in February, 2009. Observations were made on the number of plants transplanted that survived, the total number of dead plants, the number of dead plants due to bacterial wilt, the number of plants that survived to harvest, the number of tubers harvested, the number of tubers affected by *R. solanacearum*, the number of rotted tubers and the yield in metric tons per hectare.

Table 1: The incidence of *R. solanacerum* on five potato varieties in bacterium infested soil at Sotuba Station, 2009

Varietes	No. Of dead plants	No. Killed by Rs.	No. Surviving to harvest	No. of produced tubers	No. of tubers with Rs.	Nombre of rotted tubers	Yield in Ton metric/ha
Spunta	7	4AB	1B	2B	0	0	1.423AB
Mondial	8	8A	1B	1B	0	1	0.22B
Claustar	9	6A	0B	0B	0	0	0.00B
Vrac	8	6A	3A	6A	1	2	2.17A
Liseta	3	1B	2AB	3AB	0	1	0.43B
Mean	6.92	4.96	1.40	2.44	0.32	0.72	0.85
CV%	55.85	61.94	104.73	114.02	302.17	232.82	130.99
L .s. d	5.18	4.11	1.96	3.73	1.29	2.25	1.49
Signification	**NS**	**S**	**S**	**S**	**NS**	**NS**	**S**

The results were analyzed with the software MSTat-C alpha = 0.05. There was a significant difference between treatments for infection of *R. solanacearum* (Table 1) in the number of plants died due to *R. solanacerum*, number of plants harvested, number of tubers harvested and yield. Liseta showed the best tolerance to the disease in soil infested, followed by Spunta while Mondial was found to be the most susceptible followed by claustar and the table potato bought at the market.

Incidence and abundance of insect pests and disease epidemiology

The incidence of potato diseases and insect pests of potatoes were investigated in the Fouta Djallon region of Guinea. Bacterial agents responsible for diseases were *Erwinia carotovora* (7.5%), *Ralstonia solanacearum* (8.27%), and *Streptomyces* (2.5%), while fungi responsible for rot included *Alternaria solani* (26.0%), *Fusarium sp* (9.1 %), *Rhizoctonia*, *Stemphylium sp* (12.6%) and *Botrytis sp* (14.5%). The proportion of sampled plants that had viral attack was 7.5%. Insect pests observed were the potato tuber moth, *Phthorimaea operculella* (22.7%), the variegated grasshopper, *Zonocerus variegatus* (14.81%), the noctuid moths, *Agrotis ipsilon* (13.2%) and *Helicoverpa* spp. (9.2%), and the whitefly, *Bemisia tabaci* (12.0%).

Compare the yield, tolerance to pests and resistance to diseases of 4 improved potato seed varieties with an indigenous variety

Expected outputs:
Potato varieties tolerant to insect infestation and diseases will be determined.

Quality Assurance: Pesticide Safety Education

First drafts of two lessons: “The Environmental Fate of Pesticides” and “Container Management” were produced for additional pesticide safety education program support materials adapted for use in West Africa. Practicing trainers have updates and additional tools and new trainers received comprehensive training.

Conducted pesticide safety training sessions in additional sites in Mali, such as: 1) 10 villages of OPIB (L’Office du Périmètre Irrigué de Baguineda), and 2) farmers in the regions of Sikasso, Segou, and Mopti, in collaboration with IER/CRU (Regional Committee of Users).

In the summer of 2009, Issa Sidibé/OHVN conduced "train the trainer" sessions for 30 field agents based in Bamako, Bougouni, Fana, Kita, Koulikoro, Koutiala, San, and Sikasso. Subsequently, his team trained 200 farmers (7 sessions, 7 sites: Ouélessébougou, Bougouni, Sikasso, Koutiala, San, Fana, and Kita).

A comprehensive set of pesticide safety program support materials (print, electronic) were demonstrated and given to the director and staff of the Laboratoire National de Protection des Végétaux – Kindia, Guinée.

Three new lessons posted of the website.

Pesticides and IPM technology transfer training

The purpose of this activity is to train farmers and extension specialists on the use of pesticides which are of relatively low toxicity to humans and animals and have a low persistence in the environment and educate producers of methods based on IPM. Educational tools used were flipcharts and booklets on pesticides and books on IPM techniques developed by Virginia Tech, IER and OHVN. At the end of the training, booklets were distributed to producers and trainer development services, agencies, and NGOs. Seven modules have been prepared and provided to the participants. The modules were presented in Bambara.

IER organized the training of farmers on the safe use of pesticides in three areas: The first training session took place in six villages in the region of Segou (Kondogola, Niata, Ouendja, Nabougou, Fambougou and Sanogola). In these villages, training on pesticides was extensive during the "Farmers Field School" on cowpea.

Training session on pesticides at Fambougou July 2009

The training was led by: Mr. Issa Sidibe of OHVN, Mr. Ousmane Cisse of CMDT and Mr. Sidiki Traore of IER.

The training covered the various players in cotton production (trainers, farmers and storekeepers of agricultural inputs).

Quality Assurance: Pesticide Residue Training

The Laboratory of Toxicology and Environmental Toxicology and Quality Control Laboratory (ETQCL) of the Central Veterinary Laboratory of Bamako and the CERES-Locustox Foundation of Dakar are collaborators as part of the West Africa IPM CRSP Project/Quality Assurance. Personnel from both of the laboratories met at the ETQCL, September 14-16, 2009. Three scientists/laboratory directors, four laboratory technicians and two university students participated in the workshop. During the three-day workshop, participants focused on the implementation of the QuEChERS method in accordance with quality insurance according to ISO/CEI 17025. They conducted a series of analyses using the QuEChERS method with the following objectives: 1) Development of protocol describing the various stages of the multi-residue analysis of organophosphorus (OP), organochlorine (OC), pyrethroids (PY), polychlorinated biphenyls (PCBs) and carbamates (CA) using the NF EN 15662 standard (Method QuEChERS); 2) Development of the validation protocol of the QuEChERS method; 3) Review of protocols (standard operating procedure) on items of reference (analytical standards) and samples; 4) Preparation of the standard solutions and the mango samples; 5) Analysis of mango samples according to the QuEChERS method; 6) Review of the protocol of checking the chain, the software of the gas liquid chromatograph and the recovery rate.

West Africa Pesticide Programs (http://wapp.biochem.vt.edu) web site as a networking tool for pesticide chemists and safety educators

The web site provides a central location where chemists can access information, and it continues to showcase the activities of pesticide residue chemists to various stakeholders.

Regional Integrated Pest Management Research and Education for South Asia

Ed Rajotte, Penn State University

Bangladesh

ANM Rezaul Karim

The IPM research program in Bangladesh was carried out for developing IPM tactics and packages for management of major pests of high value vegetable crops, such as eggplant, tomato, country bean, cucumber, sweet gourd, okra, cabbage and other vegetables of local importance. In addition, IPM technologies developed through IPM CRSP projects were disseminated through four non-governmental organizations (CARE-Bangladesh, MCC, Action Aid-Bangladesh and Practical Action-Bangladesh

Survey of spider mites and development of IPM package

S. N. Alam, N. K. Dutta, M. K. Uddin, A.N.M. R. Karim, and Edwin G. Rajotte

Surveys were conducted for the incidence of red spider mite, *Tetranychus* spp., which has recently emerged as one of the major pests in different vegetables in six major vegetable growing areas of Narsingdi, Comilla, Jessore, Bogra, Rangpur and Sylhet districts. Mite population was counted with the help of a 10x magnifying glass from 6 plants of each plot, and damage severity was recorded from three non-sprayed fields (IPM field) and three fields sprayed frequently with pyrethroid insecticides.

Survey results showed that the number of red spider mite was highest on eggplant, followed by cucumber, aroids, ribbed gourd and teasel gourd during both the seasons of 2008 and 2009. No infestation was observed on bitter gourd (Table 1). Damage severity was highest in Jessore area on all crops, followed by Narsingdi, Comilla, Rangpur, Bogra and Syhet. Fields receiving frequent insecticide applications had bout 10 times higher population of mite (35 to 70 mites per leaf) than the fields receiving no insecticide applications (6 to 9 mites per leaf).

To develop IPM tactics for the management of red spider mite, experiments were carried out on eggplant (variety 'Singnath'), the most frequently affected crop. The study was conducted in farmers' fields of Narsingdi district with a comparison of four miticides, to the application of neem seed kernel extract (NSKE) and a control, which was an untreated plot.

The experiment was laid out in RCB design in three replications with the following treatments: T_1- Three sprays at 15-day intervals with 'Abamectin 1.8 EC' (Vectin) at the rate of 1.2 ml per liter of water; T_2- Three sprays at 15-day intervals of miticide 'Propargite' (Sumite) at the rate of 1.0 ml per liter of water; T_3- Three sprays at 15-day intervals of miticide 'Spiromesifen 24EC' (Oberon) at the rate of 1.0ml per liter of water; T_4- Three sprays at 15-day intervals of miticide 'Fenazaquin 10EC' (Magister) at the rate of 1.0ml per liter of water; and T_5- Three sprays of neem seed kernel extract (NSKE) at the rate of 50g per liter of water at 15-day interval; T_6- Spraying with plain water (control) ; and T_7- Untreated control.

Table 1. Number of red spider mites per leaf in different vegetables in the surveyed areas during the 2008-2009 winter and summer seasons.

Crops	Narsingdi		Jessore		Bogra		Comilla		Rangpur		Sylhet	
	2008	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
Eggplant	63.8	54.2	72.8	73.3	39.4	41.3	62.4	65.7	-	42.4	-	54.8
Cucumber	24.4	21.3	31.9	33.3	25.4	26.5	22.3	25.4	-	12.3	-	23.1
Aroids	7.4	6.6	28.4	23.3	14.2	15.6	18.9	21.4	-	16.7	-	16.8
Snake gourd	2.3	3.6	6.8	8.5	2.8	3.4	2.2	2.8	-	3.2	-	3.8
Teasel gourd	0.0	0.0	2.5	3.6	0.0	1.2	1.4	2.2	-	0.0	-	1.2
Ribbed gourd	4.4	5.3	11.2	9.7	2.8	1.6	3.8	4.5	-	3.3	-	4.9
Bitter gourd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	-	0.0

Applications of miticides and NSKE significantly reduced the number of red spider mites by about 58% to 84%; fenazaquin 10EC and abamectin 1.6EC were the most effective ones giving respectively 84.4% and 82.5% control of the mites over the control treatment, followed by NSKE (72.7%), Spiromesifen (63.9%) and Propargite (58.8%). Due to insecticide resistance, unrestricted application of pyrethroid insecticides should be stopped to avoid resurgence of red spidermite. The results of the study indicated that strategically timed conservative applications of fenazaquin 10EC and abamectin 1.6EC will effectively control red spider mite populations as a curative measure, but applications of NSKE were sufficient as an effective alternative to replace pesticides for production of healthy crops.

Evaluation of eggplant and tomato germplasms for resistance to fruit and shoot borer, jassid, bacterial wilt and root-knot nematode

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Fruit and shoot borer (FSB), jassid, bacterial wilt (BW) and root-knot nematode (RKN) are the major damaging pests of eggplant. BW and RKN are highly damaging to tomato crops. In absence of any effective control measures, farmers rely solely on the use of pesticides without achieving any satisfactory control of the pests. Several resistant eggplant and tomato lines have been identified by carrying out research in previous years. Through continued research, three eggplant varieties, such as BARI Begun-6, BARI Begun-7 and BARI Begun-8 having multiple resistances to FSB, jassid, BW and RKN were released in 2006. Because of their differences in ecological adaptability and consumer acceptability, more pest-resistant varieties are needed to offer more options and flexibility to the farmers for their cultivation in different areas. Developing improved tomato variety is more important as no pest-resistant tomato variety is available in Bangladesh.

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 inoculum and RKN. The BW-sickbeds contained *Ralstonia solanacearum* bacterium having a population density of 1.7 x 10^8 CFU/ml of water by dilution plate method. The RKN-sickbeds were prepared containing 2000-3000 RKN larvae per kg of soil in the winter season and 3000-4000 RKN larvae per kg of soil in the summer season.

Evaluation of eggplant against FSB: Seventeen promising eggplant lines that were selected last year were planted in 10M x 1M plots in three replications using split plot design. Records were taken on shoot and fruit infestations by FSB and jassid, and plant mortalities due to BW infection. Out of 17 test lines, seven lines (Bholanath, BD-2680, BD-2681, BD-2682, BD-2683, BD-2688, and BB-332) were selected based on their better resistance to FSB, jassid, BW and fruit yield (Table 2). These lines performed well last year also, and they will be put in regional yield trials for final selection.

Table 2: Performance of eggplant lines against FSB, jassid and BW, BARI farm, Gazipur, 2008-2009.

Lines	Fruit infestation by FSB (%)	Jassid/leaf (No.)	Mortality by BW (%)	Yield/plant (Kg)
Bholanath	15.6	1.5	11.7	1.2
BD-2680	29.7	0.7	5.9	1.1
BD-2681	10.4	0.5	17.6	0.9
BD-2682	13.6	1.8	5.9	1.2
BD-2683	10.3	0.7	35.3	1.2
BD-2688	11.7	0.7	5.6	0.5
BB-332	15.6	1.3	5.9	0.5

Evaluation of eggplant and tomato lines against BW: Ten summer eggplant lines and 26 winter eggplant lines were evaluated in BW sickbeds in three replications using complete randomized design. There were 10 plants per replication planted in one meter long rows, 50 cm apart and with 30 cm spacing between plants. Weekly records were taken on BW wilted plants. In the summer season, all the entries excepting BARI Begun-8 were susceptible. In the winter season, five entries showed resistant reaction exhibiting 6.7% to 20% wilting (Table 3).

Table 3: Eggplant lines showing resistance to bacterial wilt in sickbeds.

Eggplant accessions	BW wilting (%)	Reaction
SM-0010	20.0	R
SM-0015	16.7	R
SM-0074	16.7	R
SM-0116	13.3	R
SM-0118	6.7	R

Thirty one summer and 23 winter tomato lines were evaluated against BW in sickbeds. Three-week old seedlings of tomato were transplanted at 20cm spacing in one-meter long rows, 50 cm apart in three replications. Only one line (FP_1 x MP_3) showed resistance (13.3% wilting) in the summer season and two (WHTC-10 and VRT-8-1-3-1-1) were resistant (13.3 % and 20% wilting) in the winter season.

Evaluation of eggplant and tomato against RKN: One and a half month old seedlings of 23 eggplant and 31 tomato lines in each season of winter and summer were transplanted separately in sickbeds in two replications at 20cm spacing in one-meter rows, 30 cm apart. After 45 days of planting, the plants were uprooted carefully, washed in running water and examined for RKN galls. The root system was indexed following a 0-10 scale: 0=roots without gall, and 10=roots with severe gall. The disease reaction was designated as 0=highly resistant (HR); 1-2=resistant (R); 2-3=moderately resistant (MR); 3-4= moderate susceptible (MS); 4-6= susceptible (S); and 6-10= highly susceptible (HS). Among 23 eggplant germplasms, nine lines (SM-017, SM-0004, SM-0013, SM-0072, SM-0059, SM-0043, SM-0048, 1 x 5, and 1 x 14) were selected as resistant. Among the tomato lines, two lines (P_1 x P_2 and FP_1 x MP_3) in the summer season and one (VRT-8-1-3-2-1) in the winter season exhibited resistant reaction. All the selected materials will be retested next year for confirmation.

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 depending on the acceptability to the farmers, or they may be used as resistant donors for developing improved varieties.

Screening pumpkin varieties for resistance to PRSV and WMV2 viruses

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The production of pumpkin is seriously constrained due to the attack of a complex of viruses, particularly the *Papaya ring spot virus* (PRSV) and *Water melon 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 ELISA tests. Among them, two virus-resistant lines having good horticultural qualities were released as varieties by the National Seed Board in 2007. These are: BARI Misti Kumra-1 (Line No. PKDS-16-4-1-10-2) and BARI Misti Kumra-2 (Line No. PK-187-2-1-14-1-10). BARI Misti Kumra-1 is an early winter variety having high degree of resistance to PRSV and WMV2.

During 2008-2009, three advanced pumpkin lines that were selected in the previous year were retested for confirming the results. The materials were planted in unit plots of 10M x 2.5M in November 2008 in three replications using RCB design at BARI farm, Gazipur. The performance of PKDS-187-6-5-9-6-2 was excellent in respect of virus resistance and horticultural traits. This line has been selected for recommendation as farmer's 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, and they may be considered for recommendation after further purification and improvement of their homozygosity.

Screeing of cucumber varieties for resistance to virus diseases

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Damage to cucumber (*Cucumis sativus*) is caused by a complex of viruses, such as

Water melon mosaic virus (WMV), *Cucumber green mottle mosaic virus* (CGMV), and *Papaya ring spot virus* (PRSV) is the main constraint for its satisfactory production. A series of trials were conducted to select promising virus-resistant cucumber lines. In the winter season, 20 cucumber lines that were selected in the previous year were evaluated at BARI farm, Gazipur in three replications. Six lines that had 8-13% virus infection with low and medium disease severity were selected and selfed for further evaluation in the next season. The six selected lines were CS-0063, CS-0067, CS-0071, CS-0075, CS-0079, and CS-0080. As the incidence of virus diseases is usually more prevalent and severe during the summer season, the same lines (20 entries) that were tested in the winter season were again evaluated in the summer season and six lines (CS-0034, CS-0050, CS-0075, CS-77, CS-79 and CS-0080) were selected based on their lower virus infection (26.7% to 60%) and better agronomic qualities, and these entries were again evaluated during the summer season and two best performing lines (CS-0079 and CS-80) were selected based on their lower virus infection, earliness (68 days for first harvest) and higher yields (24-26t/ha). These two lines will be evaluated in regional yield trials for their final selection and recommendation to the national seed board for release as varieties.

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

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Yellow vein mosaic virus (YVMV) disease is the main constraint for the production of okra (*Abelmoschus esculentus*). Every year 60% to 80% of the crop is lost due to YVMV infection. Experiments conducted during the previous years have shown that virus-resistant materials are available in local and exotic germplasms. During 2008-2009, two trials were conducted to evaluate selected okra lines for their resistance to YVMV disease which was widely prevalent throughout the testing periods. In 2008 summer season, 20 okra germplasms that were selected in the previous year were evaluated at BARI farm, Gazipur in three replications using RCB design under natural field conditions for their reaction to the infection of YVMV. Bulk of the test entries was severely infected by YVMV. Symptomatically, only six lines (OK-0145, OK-0146, OK-0147, OK-0148, OK-0170, and OK-0212) exhibited resistant reaction having 15-50% YVMV infection. These lines were selfed and planted for further evaluation in 2009 summer season.

In 2009 summer season, 14 selected okra lines, including the six lines selected in 2008 summer season, were evaluated under natural conditions in the field. YVMV infection rates on the all entries ranged from 25% to 90%. Four entries (OK-0137, OK-0146, OK-0147, and OK-0212) were selected based on their moderate virus infection (25% to 40%), earliness, better agronomic characters and higher yields. The selected lines were selfed for their use in regional yield trials (RYT) in the next season.

Results of the experiment showed that moderate YVMV resistance is available in local okra germplasms and it is possible to develop YVMV-resistant improved okra varieties by undertaking proper breeding procedures.

Screening of country bean varieties for resistance to pod borer and virus disease

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The pod borer (*Maruca vitrata*) and *Yellow vein mosaic virus* (YVMV) are the two most damaging pests of country bean (*Dolicos lablab*). Ten country bean lines that were selected in the previous year were evaluated at BARI farm, Gazipur during the 2008-2009 winter season. The materials were planted in 10m x 1m plots, each plot containing 6 plants. No plant protection measure was taken. Different horticultural characteristics including yield and infestations of pod borer and YVMV were recorded. Out of 10 test entries, four lines having better reactions to pod borer and YVMV and better horticultural traits were selected. These selected materials will be tested in 'regional yield trials (RYT)' in various locations (Table 4) and the best performing lines will be recommended for release as varieties. Development of resistant variety will be a breakthrough in the production of healthy country bean both for domestic consumption and export purpose.

Table 4: Country bean lines possessing better horticultural traits and showing higher resistance to pod borer and YVMV infestations.

Country bean lines	**Days to 1st flower**	**Pod borer infestation (%)**	**Virus incidence (%)**	**Pod yield (t/ha)**
CB-0203	106	9.2(MR)	11.7	14.7
CB-0223	102	5.9(MR)	6.4	12.4
CB-0230	98	11.6(MS)	2.4	14.2
CB-0294	96	13.2(MS)	8.0	15.3

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

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Cabbage (*Brassica oleracea* var. *capitata*), country bean and tomato (*Solanum lycopersicum*) are high value vegetables in Bangladesh. The diamond back moth (*Plutella xylostella*) and armyworm (*Spodoptera litura*), two leaf-eating insect pests, are the most damaging pests of cabbage. Country bean production is seriously constrained due to the damage caused by pod borers (*M. vitrata* and *H. armigera*). Aphid is also an important pest. Tomato, on the other hand, is damaged by the white fly transmitted *Tomato leaf curl virus* (TLCV) and pod borer, *H. armigera*. Trials were continued for the third year in 2008-2009 at BARI farm in Gazipur and in farmers' fields to develop IPM packages for vegetables.

(a) Trials for cabbage: The trials were carried out in farmers' field at Nangarpur village of Jessore and at BARI farm, Gazipur during the 2008-2009 winter season. Two treatments were laid out in RCB design in three replications in 20M x 20M unit plots: 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 chilonis* at the rate of one gm parasitized eggs/ha/week, and (c) weekly release of larval parasitoid *Bracon hebetor* at the rate of 800-1000 adults/ha/week; and T2- Non-IPM practice of foliar spray with synthetic pyrethroid insecticide (Cymbush 10EC) at the rate of 1ml/liter of water every three days. The IPM plots were placed about 100 meters away from the non-IPM ones.

Infestations of cabbage heads by army worm and diamond back moth in non-IPM fields were 5.5 times higher in Jessore and 7.5 times higher at BARI farm, Gazipur. The number of caterpillars of army worm and diamond back moth (DBM) recovered from the cabbage heads were 2.5 to 5.5 times higher in non-IPM plots. As a result, the IPM fields produced about 1.3 times higher yields in Jessore and 1.4 times higher at BARI farm. Moreover, the cost of pest control in IPM practice was 1.8 to 2.6 times lesser than that of the non-IPM fields (Table 5). These results confirm that, by utilizing IPM practices, farmers can produce healthy crops of cabbage and earn higher economic benefit without any use of pesticides.

Table 5. Performance of IPM and non-IPM practices in controlling DBM and armyworm in cabbage

Practice	**Farmers' fields, Nangarpur village, Jessore**			**BARI farm, Gazipur**		
	Infested cabbage heads (%)	**Yield (t/ha)**	**Pest control cost (Tk/ha)**	**Infested cabbage heads (%)**	**Yield (t/ha)**	**Pest control cost (Tk/ha)**
IPM	5.8±0.9b	57.9±0.7b	8,000	2.9±0.9b	61.4±0.6b	8,500
Non-IPM	31.8±1.76a	44.8±0.9a	14,500	21.8±0.8a	44.8±0.8a	22,000

(b) Trials for Country bean: Trials for developing IPM package for country bean pests were continued at BARI farm, Gazipur and in farmers' fields at Gaidghat village of Jessore district. The following three treatments were laid out in RCB design in three replications in unit plots measuring 20Mx20M: 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 *B. hebetor* at the rate 0f 800-1000 adult/ha/week; (b) weekly release of egg parasitoid *T. evanescens* at the rate of one gm parasitized eggs/ha/week, and larval parasitoid *B. hebetor* at the rate of 800-1000 adults/ha/week; and (c) Farmers' practice (Non-IPM) of foliar spray of synthetic pyrethroid insecticide (Cymbush 10EC) at the rate of 1 ml/liter of water every three days. Records were taken on pest infestations, yield and pest control costs.

Results of three years' trials from 2006-2007 to 2008-2009 consistently showed that the average infestations of pod borers and aphids were 11.2 and 5.2 times higher in non-IPM plots than in IPM plots. Release of egg and larval parasitoids were also highly effective (Table 6). As a result, the average yields in IPM fields were 2.2 times higher. Use of IPM package also reduced the pest control costs by about 80% (Table 7). The results clearly indicated that IPM practice is highly effective to control pod borer and aphid infestations, and healthy and higher production of country bean is possible without pesticide use.

Table 6: Performance of IPM and non-IPM practices in controlling pod borers and aphid in country bean at the BARI farm, Gazipur and farmers' field in Jessore

Treat-ment	**2006-2007**			**2007-2008**			**2008-2009**		
	Borer infested flowers (%)	**Borer infested pods (%)**	**Aphid infested flowers (%)**	**Borer infested flowers (%)**	**Borer infested pods (%)**	**Aphid infested flowers (%)**	**Borer infested flowers (%)**	**Borer infested pods (%)**	**Aphid infested flowers (%)**
IPM package	5.7±1.2 b	2.7±1.2 b	4.5±1.3 b	3.2±0.9 a	1.4±0.4 a	2.5±0.2 a	2.1±0.6 a	1.6±0.3 a	3.1±0.6 a
Bio-agents only	-	-	-	7.4±2.1 b	6.9±0.8 b	7.9±1.4 b	4.8±0.9 b	4.2±1.1 b	12.8±1.8b
Non-IPM	22.9±1.3a	26.4±1.6a	10.4±1.7a	21.3±2.1c	25.4±2.6c	19.4±2.7c	8.2±1.3 c	10.0±1.8c	17.8±2.3c

Table 7. Performance of IPM and non-IPM practices on yield of country bean and pest control costs at the BARI farm in Gazipur and at farmers' field in Jessore.

Treatment	**2006-2007**		**2007-2008**		**2008-2009**	
	Cost of pest control (Tk/ha)	**Yield (t/ha)**	**Cost of pest control (Tk/ha)**	**Yield (t/ha)**	**Cost of pest control (Tk/ha)**	**Yield (t/ha)**
IPM package	12,000	10.5±0.9b	12,500	18.6±1.9b	13,000	22.3±0.8c
Bioagents only	-	-	6,400	15.4±1.2b	7,000	16.5±0.7b
Non-IPM	22,000	4.4±0.4a	22,000	8.0±0.7a	23,000	12.3±1.3a

(c) Trials for tomato: Trials for developing an IPM package for tomato pests were continued during 2008-2009 winter season at BARI farm, Gazipur and in farmers' fields in Bagharpara of Jessore district. The following two treatments were established in 15M x15M unit plots in three replications in RCB design: 1) 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 *T. evanescens* at the rate of one gm parasitized eggs/ha/week, (d) weekly release of larval parasitoid *B. hebetor* at the rate of 800-1000 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/liter of water) every three days.

The 2008-2009 results were similar to those obtained in the past two years. The use of IPM package was highly effective in controlling the infestations of fruit borer, white fly and TLCV at both the locations (Table 8). As a result, the yield in IPM practice was 1.3 times higher at BARI farm and 1.2 times higher at Jessore. Moreover, the costs of pest control in non-IPM fields were twice as much as that of IPM practice (Table 9).

Table 8: Performance of IPM and non-IPM practice in controlling insect pests and diseases in Tomato, 2008-2009

Practice	BARI farm, Gazipur			Farmers' fields, Bagharpara, Jessore		
	Borer damage (%)	Whitefly per leaf (No.)	Virus infested plants (%)	Borer damage (%)	Whitefly per leaf (No.)	Virus infested plants (%)
IPM	1.8±0.3b	0.5±0.1b	12.3±0.9b	1.0±0.5b	0.6±0.2b	10.4±0.7b
Non-IPM	7.4±0.8a	1.1±0.1a	43.0±2.2a	9.4±0.8a	2.5±1.1a	64.1±2.1a

Table 9. Effects of IPM and non-IPM practices on pest control costs and yield of tomato, 2008-2009

Practice	BARI farm, Gazipur		Farmers' fields, Goispur village, Pabna	
	Pest control cost (Tk/ha)	Yield (t/ha)	Pest control cost (Tk/ha)	Yield (t/ha)
IPM	10,000	35.8±0.8b	10,000	44.8±0.9b
Non-IPM	20,000	28.3±0.7a	21,000	37.8±0.7a

The results of the last three years consistently showed that country bean, cabbage and tomato crops can be successfully grown by utilizing the IPM packages by integrating manual destruction of pests, release of parasitoids and use of pest-resistant crop varieties. IPM practices by avoiding pesticide use will ultimately help establish natural biological control system and will make the pest control system easier for the cultivators.

Field trial of IPM package for cucurbit fruit fly and borer complex in bitter gourd crop

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The cucurbit fruit fly, *Bactrocera cucurbitae*, is the most destructive pest of all the cucurbit crops grown in Bangladesh. Recently, three borer species (*Spodoptera litura*, *S. exigu*a and pumpkin caterpillar) have emerged as highly damaging to bitter gourd crops in many areas. Baiting with a synthetic sex pheromone (cuelure) has become widely popular among the farmers because of its excellent effectiveness against the fruit fly and high economic returns. Trials carried out in previous years showed that mass release of the egg parasitoid, *T. evanescens*, and a larval parasitoid, *B. hebetor*, were highly effective to control the borer pest complex.

During 2008-2009 cropping seasons of bitter gourd, two trials were conducted in farmers' fields of Nangorpur village in Jessore district to determine the effectiveness of an IPM package consisting of (a) sanitation-weekly destruction of infested fruits; (b) trapping of fruit fly with 'cuelure' pheromone baiting; and (c) weekly release of the egg parasitoid, *T. evanescens*, at the rate of one gm eggs per ha and larval parasitoid, *B. hebetor*, at the rate of 1000-1200 adults per ha. The trials were laid out in RCB design with four dispersed replications to compare with a control treatment of farmers' practice of pesticide sprays (pyrethroid) at 2-3 day intervals.

Results showed that *S. litura* was the dominant one (72-78%) among the borer pests, followed by *S. exigua* (11-19%) and pumpkin caterpillar (9-13%) in both IPM and farmers' practices in both the cropping seasons of 2008 and 2009. IPM package, however, was highly effective in controlling the borer pests as well as the cucurbit fruit fly. Damages caused by borers and fruit fly were 93% to 95% less in plots receiving IPM package treatments, resulting in 62% higher yields in 2008 and 28% in 2009. Moreover, pest control costs in IPM treatments were 62% less in 2008 and 65% less in 2009 (Table 10). The results confirmed that the farmers can grow healthy bitter gourd crops by avoiding pesticide use and utilize IPM package by integrating sanitation, pheromone baiting and mass-release of egg and larval parasitoids for effective control of the pest complex in bitter gourd crop.

Table 10: Performance of IPM package for controlling fruit fly and borer complex in bitter gourd crop in Nangorpur village, Jessore

Practice	**Fruit fly damage (%)**		**Borer damage (%)**		**Yield (t/ha)**		**Pest control cost (Tk)**	
	2008	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
IPM package	1.0±0.2a	1.4±0.8a	2.0±0.3a	2.3±0.9a	28.5±0.7b	31.3±0.9b	12,000	12,000
Farmers' practice	18.3±1.8b	21.1±1.9b	29.5.0±2.2a	32.2±3.4b	17.6±0.9a	24.5±0.8a	32,000	34,000

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

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

Agricultural management systems are known to affect beneficial and harmful microbial populations, directly or indirectly, in the soil. There are three main trophic groups of nematodes: (a) plant parasitic nematodes that feed on plants, (b) microbivorous and bacteria feeding nematodes that feed primarily on fungi, bacteria and various decayed products, and (c) carnivorous nematodes or predatory nematodes that feed on other nematodes and small soil inhabiting animals. Soil management with IPM or non-IPM practices has impact on the populations of harmful and beneficial nematodes.

During 2008-2009, soil samples were collected from IPM and non-IPM research fields of cabbage and tomato crops at BARI farm, Gazipur and from eggplant crop of farmers' fields at Kahalu of Bogra district. In IPM system, the crops were grown by using different organic products (e.g., Tricho-compost, Tricho-leachate, vermicompost, poultry refuse, and *Trichoderma harzianum* on barley as carrier). The non-IPM treatment consisted of the use chemical fertilizers at recommended rates. All the organic products for IPM treatment were incorporated in the soil, excepting Tricho-leachate which was sprayed on the crop foliage. 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 IPM plots at BARI farm (Gazipur) and in farmers' fields in Bogra belonged to the species of *Meloidogyne*, *Hoplolaimus*, *Helicotylenchus* and *Tylenchus* genera. As compared with the use of chemical fertilizers and other treatments, the use of poultry refuse and Tricho-compost significantly decreased the populations of plant feeding nematodes and increased the populations of bacterial feeders. Fungal feeders and omnivores were not affected much probably because of the fact that the soils of crops were subjected only for the first time to organic treatments (Table 11).

The trials conducted on cabbage and tomato crops at BARI farm (Gazipur) also showed that Tricho-compost was highly effective to reduce the number of plant feeding nematodes and increase the number of bacteria feeding nematodes.

The overall results therefore confirm that adoption of IPM practices will improve soil health by decreasing the populations of plant parasitic nematodes and increase the populations of bacteria feeding nematodes in a cumulative manner.

Table 11: Trophic abundance (No. per 10g soil) of soil nematodes in eggplant field at Kahalu in Bogra district, 2008-2009

Treatments	Plant parasitic	Fungal feeder	Bacteria feeder	Omnivorous
Poultry refuse	5.3b	18.0a	345.3a	8.3a
Tricho-compost	6.0b	20.7a	313.a	7.3a
Tricho-leachate	15.3a	16.7a	143.7cd	7.3a
T. harzianum	13.0a	18.3a	196.7bc	8.0a
Vermicompost	14.0a	20.3a	253.3b	7.7a
Chemical fertilizers	18.0a	16.0a	135.7d	7.7a

Mass-rearing of parasitoids and their efficacy tests against vegetable pests

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Trichogramma egg parasitoids and *B. hebetor*, a larval parasitoid, are abundant and active in vegetable fields attacking various damaging pest insects. But the indiscriminate use of pesticides by the farmers destroyed their populations utterly from the vegetable fields. In order to augment their populations in the vegetable fields through mass release, mass production of these parasitoids in the greenhouse were continued in 2008-2009. The mass-reared populations were tested under micro-plot conditions for their performance in controlling pests of eggplant and cabbage.

Mass-rearing of larval parasitoid, *B. hebetor*: For mass-rearing *B. hebetor*, firstly, a parent stock of wax moth, *Galleria mellonella,* was developed in a honeycomb placed in glass jars. Fully grown wax moth larvae were reared in large numbers by allowing 1st to 2nd instar larvae of wax moth to feed on artificial diet for 18-20 days. The artificial diet was prepared by mixing wheat flour, maize flower, milk, animal fat, sugar and yeast and autoclaved at 125^{0}C and at 1.5 PSI for 70 minutes. The full grown larvae were then transferred to corrugated paper sheets placed in a plastic bottle (200 larvae per bottle) for pupation within the wrinkled spaces of the corrugated sheets. Soon after transferring the wax moth larvae to the corrugated paper sheets, 40 adult *B. hebetor* (30 female and 10 male with a honey cube as their food) were released inside the plastic bottle for parasitism, egg laying, pupation and adult emergence. The mouth of the bottle was covered with a piece of black cloth.

All the wax moth larvae were parasitized (100%) by *B. hebetor*. The adults of *B. hebetor* emerged in 8-9 days (average 8.7 days) starting from the date of parasitism. The number of *B. hebetor* emerging from each larva of wax moth averaged 4.5. Adults of *B. hebetor* lived for 21-24 days (average 22.5 days) on honey.

Mass-rearing of egg parasitoid, *Trichogramma* spp. on the eggs of rice moth, *Sitotroga cerealella*: Rearing of *Trichogramma* species on the eggs of rice moth, *Sitotroga cerealella* seemed to be easier than rearing on the eggs of rice meal moth, *Corcyra cephalonica*. In the present study, the protocol was standardized for mass-rearing *Trichogramma* spp. on the eggs of *S. cerealella* using the following procedure. Five kgs of wheat grains were soaked in boiled water for 2-3 minutes and after draining out the excess water the grains were spread over galvanized tin trays (60cm x 50cm; each tray containing 2.5Kgs) and then mixed with one gm eggs of rice moth and kept undisturbed for 5-6 days. A requisite amount of water was then mixed with the grains by gentle stirring and after 22-25 days the wheat grains in the trays became infested with rice moth larvae and they were kept in mass-rearing chamber for adult emergence.

Thousands of rice moths emerged within the mass-rearing chamber were collected separately and released in a glass cylinder, one of its mouths being covered by a 32-mesh wire net, for mating and egg laying. The adults laid eggs in large numbers on the inside wall of the cylinders. After separating the adults and their body parts and scales from the eggs by holding the cylinders near an exhaust fan, the eggs were collected from the walls of the cylinders by brushing and then passed through a fine-mesh sieve to further clean the eggs from dirt. Five gms of fresh eggs were then taken in a long cylinder, moistened by keeping in a refrigerator for a few minutes, and then the cylinder was rolled in order to spread the eggs over the inside walls of the cylinders. Then a vial containing one gm of eggs parasitized with *Trichogramma* spp. was inserted in to the cylinder and they were kept under fluorescent light at $25^0C \pm 2^0C$ for 9-11 days.

Almost all the eggs of rice moth were parasitized in 9-11 days. The parasitized eggs were preserved in desiccators at $3\text{-}4^0C$ and 75-85% RH for 1-1.5 months for using them in greenhouse or field trials.

Parasitism efficiency of two species of egg parasitoid, *T. chilonis* and *T. evanescens*, for controlling eggplant fruit and shoot borer under micro-plot conditions: The egg parasitoids, *T. chilonis* and *T. evanescens* are widely prevalent in eggplant fields of the country. Their populations were however utterly destroyed by the farmers through indiscriminate use of pesticides over years. Augmentation of the parasitoid populations through artificial mass-release and avoidance of pesticide applications can overcome the problem. Keeping the above objective in view, replicated micro-plot trials were conducted at BARI farm, Gazipur to determine the efficiency of the above parasitoids for controlling eggplant FSB (Table 12). Eggplant seedlings were transplanted in unit plots measuring 4m x 4m and four plants in the middle of the plot were covered with 70-mesh nylon neting (1m x 1.5m x 1.5m) when the plants were 40 days old. Twenty days after setting the net cover, two pairs of newly emerged male and female adults of FSB were released in the micro-plots. After one day of FSB release, 500 adults of each of the species of *Trichogramma* egg parasitoids were released within the net-covered micro-plots according to the following treatments: (a) FSB + *T. chilonis*; (b) FSB + *T. evanescens*; (c) Only 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.

Table 12: Performance of two *Trichogramma* egg parasitoids against eggplant FSB in micro-plot tests, BARI farm, Gazipur, 2006, 2007, 2008 and 2009 summer seasons.

Treatments	**Eggplant fruit and shoot borer infestation (%)**			
	2006	**2007**	**2008**	**2009**
FSB + *T. chilonis*	4.7±0.5a	9.7±1.6a	2.5±0.8a	3.6±1.0a
FSB + *T. evanescens*	12.8±1.6b	16.8±1.2b	9.8±1.0b	10.6±1.0b
FSB only without parasitoid	59.7±5.3d	56.2±5.4d	64.4±2.5d	69.3±3.6d
Natural FSB infestation	38.3±3.8c	33.6±1.8c	26.5±2.8c	22.4±3.0c

Results of four years from 2006 to 2009 show that both species of *Trichogramma* are highly efficient in controlling FSB infestations, *T. chilonis* being more active. Micro-plots treated with *T. chilonis* had the lowest shoot infestation consistently for four years from 2006 to 2009 (4.7%, 9.7%, 2.5%, and 3.6%, respectively). Shoot infestation in micro-plots with FSB only (without parasitoids) were highest ranging from 56.2% to 69.3%, while shoot infestation under natural conditions (without net cover) ranged from 22.4% to 38.3% (Table 12). As both the species of *Trichogramma* egg parasitoids are highly efficient in parasitizing FSB eggs, they can be utilized for mass release for controlling the FSB effectively.

Parasitism efficiency of three species of *Trichogramma* egg parasitoids and the larval parasitoid, *B. hebetor*, for controlling leaf-eating insect pests of cabbage under micro-plot conditions: The diamond back moth (DBM), *P. xylostella*, and the armyworm, *S. litura*, are the two most damaging pest insects of cabbage in Bangladesh. Farmers rely solely on frequent pesticide applications for controlling these pests without achieving satisfactory results. *Trichogramma* egg parasitoids and the larval parasitoid, *B. hebetor*, which can control these pests, are available in the vegetable fields, but their populations have been almost rooted out by indiscriminate pesticide applications by the farmers. In 2008-2009, micro-plot tests were continued with the above egg and larval parasitoids in order to confirm their parasitism efficiency to control DBM and armyworm.

Micro-plots, each containing 10 cabbage plants were covered with 70-mesh nylon nets (1.5m x 1.5m x 1.5m) to accommodate two sets of experiments in four replications. The cabbage plants were covered with nets when they were 30-day old and beginning to form heads. Twenty days after covering the plants with nets, four pairs of equally sexed DBM adults and two pairs of armyworm adults were released in to the micro-plots. One set of the experiments consisted of the following treatments containing the pests and egg parasitoids: (a) DBM and armyworm + *T. chilonis*; (b) DBM and armyworm + *T. evanescens*; (c) DBM and armyworm + *T. bactrae*; (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. hebetor*;

(b) DBM and armyworm + *T. evanescens* + *B. hebetor*; (c) DBM and armyworm + *T. bactrae* + *B. hebetor*; and (d) DBM and armyworm only without parasitoids. The parasitoids were released two days after the pests were introduced within netted micro-plots. Ten days after release of the parasitoids, the net covers were removed and the total number of DBM and armyworm caterpillars per cabbage plant was recorded to calculate pest infestation rates.

Results of the first set showed that infestations of DBM and armyworm were significantly lower in micro-plots where the egg parasitoids were released (7.4% – 17.4%) compared to the control plots (58.3%) 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 (Table 13).

Results of the second set with a combination of egg and larval parasitoids was more effective causing significantly much lower infestations in micro-plots with parasitoid treatments that ranged from 2.4% to 7.5% as compared to a very high infestation of 58.9% 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 (Table 14).

The results of the last two years confirm that the egg and larval parasitoids were highly efficient in parasitizing FSB eggs and larvae as reflected from lower FSB infestations in micro-plots treated with only egg parasitoids or both egg and larval parasitoids. Cabbage pests can be effectively controlled without or minimal use of pesticides if the natural populations of egg and larval parasitoids are conserved and augmented by avoiding pesticide use.

Table 13: Performance of three species of *Trichogramma* egg parasitoids against infestations of DBM and armyworm in cabbage crop in micro-plot tests, BARI farm, Gazipur, January-March, 2009.

Treatments	**Cabbage heads infested (%)**	**DBM larvae/cabbage head (No.)**	**DBM reduction(%) over control**	**Armyworm larvae/cabbage head (No.)**	**Armyworm reduction(%) over control**
DBM & armyworm + *T.chilonis*	7.4±0.7a	1.7±0.3a	77.9	7.4±0.8b	19.6
DBM & armyworm + *T. evanescens*	16.7±0.9b	2.9±0.5b	62.4	8.8±0.6c	4.3
DBM & armyworm + *T. bactrae*	17.4±1.2b	2.6±0.4b	66.2	6.4±0.7a	30.4
DBM & armyworm (control)	58.3±2.3c	7.7±1.1c	-	9.2±1.1c	-

Table 14: Performance of combinations of *Trichogramma* egg parasitoids and a larval parasitoid *Bracon hebetor* against infestations of DBM and armyworm in cabbage crop in micro-plot tests, BARI farm, Gazipur, January-April, 2009

Treatments	**Cabbage heads infested (%)**	**DBM larvae/cabbage head (No.)**	**DBM reduction (%) over control**	**Armyworm larvae/cabbage head (No.)**	**Armyworm reduction (%) over control**
DBM & armyworm + *T.chilonis* + *B. hebetor*	2.4±0.4a	0.9±0.2a	89.6	1.6±0.2	87.1
DBM & armyworm + *T. evanescens* + *B. hebetor*	6.3±0.5b	2.1±0.6b	75.9	1.9±0.5	84.7
DBM & armyworm + *T. bactrae* + *B. hebetor*	7.5±0.9b	1.9±0.3b	78.2	1.8±0.4	85.5
DBM & armyworm (control)	58.9±2.9c	8.7±1.1c	-	12.4±1.4	-

Effectiveness of three isolates of *Trichoderma* in controlling soil-borne disease in cabbage crop

M.A. Rahman, M.S. Nahar, M. Afroz, G.N.M. Ilias, A.N.M.R. Karim, and S. Miller

The fungus species *T. harzianum* and *T. virens* are highly effective in controlling (antagonistic/inhibitory effects) various soil-borne disease pathogens, such as *Fusarium* spp., *Pythium* spp., *Sclerotium* spp. and *Phytopthora* spp., which cause foot- and root-rot diseases in seedbed nurseries and crop fields. It also controls the root-knot nematode (*Meloidogyne* spp.). However, it is known that just one isolate of *T. harzianum* may not be effective for all types of soil-borne pathogens. Last year one isolate was purified and found to be effective in controlling various soil-borne pathogens, except bacterial wilt pathogen (*Ralstonia solanacearum*). This isolate has been designated as 'BARI isolate'. Another isolate developed by an NGO known as 'Nature Development Society (NDS)' was found to be an effective bio-control agent. After purification, this isolate was cultured on PDA media and designated as 'NDS isolate'. Another isolate, *T. virens*, developed by NDS was also found to be effective for controlling various soil-borne diseases.

The effectiveness of the three *Trichoderma* isolates were tested in cabbage and Indian spinach crops and compared with plots treated with recommended doses of chemical fertilizers at BARI farm, Gazipur in 2008-2009 winter and summer seasons. The treatments were laid out in RCB design with three replications. The soils of the plots receiving *Trichoderma* treatments were incorporated with decomposed poultry refuse at the rate of 3t/ha. The *Trichoderma* isolates were grown on barley grains and were applied at the rate of 5g per pit for cabbage and 3g per pit for Indian spinach. The results of all the *Trichoderma* treatments were highly promising in both the crops of cabbage and Indian spinach. In cabbage they reduced the disease-induced plant mortalities by 50% to 64% and produced 25% to 33% higher yields. In Indian spinach, the isolates reduced root-knot nematode infestation by 55% to 60% and leaf spot disease by 64% and increased the vine yield by an average of 26.5%. BARI *T. harzianum* isolate produced the best result. This study also suggested that all the tested *Trichoderma* isolates can be used for producing Tricho-compost.

Commercial production of Tricho-compost and its performance on vegetable crops at BARI farm and farmers' fields

M.A. Rahman, M.S. Nahar, G.N.M. IIlias, S. Miller

In a series of experiments at the BARI farm (Gazipur), the fungal bio-agent, *T. harzianum*, has been found to be highly effective in controlling various soil-borne disease pathogens that cause foot- and root-rot diseases in vegetable seedbed nurseries as well as in the crop fields. It however failed to control the bacterial wilt pathogen (*R. solanacearum*). On the other hand, the use of decomposed poultry refuse has proved to be highly effective to control BW pathogen and root-knot nematode. *T. harzianum* has also been found to promote plant growth. In order to prepare a *T. harzianum*-based organic fertilizer (compost), two formulations were developed for commercial production of "Tricho-compost" so that the product could serve as an organic fertilizer as well as a control agent of various soil-borne diseases.

The first formulation of "Tricho-compost" was prepared by mixing *T. harzianum* spore suspension (3 x 10^7 cfu/ml) with various proportions of decomposed cow dung, decomposed poultry refuse, water hyacinth, vegetable waste, saw dust, ash, maize bran, and molasses at different layers inside a brick-built open-top house. After 6-7 weeks, the Tricho-compost, when completely decomposed, was brought out of the production house, dried under defused light, sieved through 5mm wire screen to eliminate course particles and heaped in a room for bagging and transportation to crop fields. During decomposition process of the Tricho-compost in the production house, the excess liquid of the compost materials leached out through an opening at the bottom of the production house. The leached liquid known as "Tricho-leachate" also contains considerable amounts of various nutrients, such as organic carbon, nitrogen, phosphorous, potassium sulphur, zinc and others.

In order to produce the Tricho-compost and Tricho-leachate in large quantities and make them commercially available, this formulation was handed over to a partner local NGO of Mennonite Central Committee (MCC) known as "Grameen Krishok Shahayak Sangstha (GKSS)" in Gabtoli upazila of Bogra district. In collaboration with MCC and technical assistance of IPM CRSP-BARI, GKSS has been successfully producing it for carrying out demonstrations in vegetable crops in farmers' fields. GKSS has applied to register this formulation of Tricho-compost under a brand name of "IPM Tricho-compost".

In collaboration with GKSS, MCC carried out five demonstrations in farmers' fields involving five farmers in Tarap Sartaj village in Gabtoli Upazila of Bogra district to assess the performance of Tricho-compost in eggplant crop. The eggplant fields receiving Tricho-compost at the rate of

1.2t/ha were luxuriant in growth and produced higher yields as compared to the ones grown with chemical fertilizers, and the farmers received an average of 21% higher profits.

At present, GKSS has a monthly production capacity of 6 tons of Tricho-compost and 400 liters of Tricho-leachate. So far, GKSS has produced 32 tons of Tricho-compost and 2,000 liters of Tricho-leachate. Impressed with the performance of the Tricho products, as many as 200 farmers have switched over to the use of Tricho products instead of chemical fertilizers which are about ten times costlier.

The second formulation of "Tricho-compost" was prepared at BARI by mixing *T. harzianum* spore suspension (3 x 10^7 cfu/ml) with various proportions of decomposed cow dung, decomposed poultry refuse, water hyacinth, vegetable waste, saw dust, maize bran, and molasses at different layers inside a brick-built open-top house. About 3.5 tons of Tricho-compost was prepared at BARI for testing their performance in cabbage, tomato, okra and red amaranth crops. Plots of different crops receiving Tricho-compost treatments (applied @1.2t/ha) had better crop stand and growth, lower disease incidence and plant mortalities and higher yields. In cabbage crop, Tricho-compost application reduced the disease-induced plant mortalities by 70% and increased the yield by 64%. In addition to reducing the incidence of foliar diseases and root-knot nematode (RKN), Tricho-compost application in tomato controlled fruit rot infection in storage by 60%, and produced 52% higher yield. Similarly, Tricho-compost applications reduced RKN infestations by 51% and 61% and increased the yields by 44% and 46% in okra and red amaranth, respectively.

Dissemination and impact assessment of the use of Tricho-compost: a new IPM technology developed by IPM CRSP-BARI

A. Hossain, M.A. Matin, A.N.M.R. Karim, and G.W. Norton

Identified by IPM CRSP-BARI scientists, an isolate of *T. harzianum*, a fungal bio-agent, has been found to be highly effective for controlling various soil-borne fungal disease pathogens and improve soil health. It is however ineffective to control bacterial wilt pathogen (*R. solanacearum*). On the other hand, soil incorporation of decomposed poultry refuse can effectively control various soil-borne fungal and bacterial pathogens, including the one of bacterial wilt disease, and root-knot nematode, and can add organic matter and plant nutrients to the soil. Based on previous studies, the IPM CRSP-BARI scientists developed a formulation for production of trichoderma-based organic fertilizer using cow dung, poultry refuse, water hyacinth, vegetable waste, sawdust, maize bran, ash and molasses as raw materials and named it "Tricho-compost". The technical formula of Tricho-compost was handed over to a local partner NGO (GKSS) of MCC based in Bogra district for commercial production and disseminate the use of Tricho-compost through demonstrations at the farm level. The local NGO, GKSS, in collaboration with BARI and MCC has been successfully producing Tricho-compost and conducted field demonstrations in farmers' fields in Gabtoli and Sariakandi upazilas of Bogra district.

In order to assess the impact of the use of Tricho-compost, 60 farmers who adopted the use of Tricho-compost (IPM farmers) were selected from different villages of Gabtoli and Sariakandi upazila and compared with another 60 farmers who did not use Tricho-compost (non-IPM farmers).

Among the selected 60 IPM and 60 non-IPM farmers, 15 farmers were selected for each kind of four vegetable crops, such as eggplant, yard-long bean, okra and cucumber. Data were collected with the help of a pre-designed survey schedule during July-August 2009 on perception of Tricho-compost technology, effectiveness of the technology, crop stand, yields and other related aspects.

The farmers were highly impressed with the performance of Tricho-compost. In absence of hands-on training, many farmers used it as top-dress in the crop rather than incorporation in the soil before planting of the crop. As a result, the crop plants failed to fully utilize the benefit of the Tricho-compost due to inadequate uptake of the elements of the Tricho-compost. In spite of this shortfall, the farmers received 14% increased yield in yard-long bean, 23% in okra, 26% in cucumber and 27% in eggplant. The Tricho-compost users also saved cultivation cost by 9% for growing yard-long bean, 5% each for okra and cucumber, and 8% for eggplant as they were able to minimize the use of chemical fertilizers and avoid use of pesticides. Crop establishment and growth were better and luxuriant in the Tricho-compost fields because of half as fewer disease-induced plant mortalities (only 5-6%) as that of the crop fields without Tricho-compost (10-15%). As a result of Tricho-compost use, the average gross margin for sampled crops increased from 21% to 61%. The Tricho-compost users also expressed their high satisfaction in respect of the quality and market demand of the produce that fetched them higher prices.

Training, education and capacity building

Supported by IPM CRSP, one scientist of BARI, Mr. M. A. T. Masud completed his PhD thesis research at the Ohio State University in molecular breeding under the supervision of Dr. Sally Miller and returned to BARI in July 2009. Another BARI scientist Mr. A. K. M. Ziaur Rahman completed a 6-month training program to carry out PhD research work at the Tamil Nadu Agricultural University in India and returned to BARI in February 2009.

Enterprise development

The demand for IPM inputs and the development of input supplying enterprises are the indirect indicators of the popularity and adoption rates of particular technologies at the farm level. Wide adoption of IPM technologies developed by IPM CRSP-BARI played a vital role in the establishment of agro-based private business enterprises for supplying various IPM inputs. Presently, three agro-based private firms (Safe Agro-Biotech Limited, Safe Agriculture Bangladesh Limited and Ispahani Biotech) are engaged in supplying various IPM inputs.

(a) **Supply of sex pheromone 'cuelure' for controlling cucurbit fruit fly:** In eight months up to August 2009, Safe Agriculture Bangladesh Limited supplied as many as 15,000 'cuelure' lures and traps that covered over 200ha of cucurbit crops. Safe Agro-Biotech Limited sold out 16,946 'curlure' lures and traps in nine months of 2009 that covered about 240ha. Similarly, Ispahani Biotech, which entered the market very recently, covered about 720 ha of cucurbit crops by supplying 50,415 lures and traps. The above distributors therefore a covered a total area of about 1,160 ha by supplying 'cuelure' pheromone for controlling cucurbit fruit fly in different areas of the country.

(b) **Supply of egg and larval parasitoids for controlling lepidopteran pests of vegetables:** The above three agro-enterprises also produced and supplied as many as 8,945g of *Trichogramma* egg parasitoids and 8,836 jars of *Bracon* larval prasitoids that covered about 1,100 ha of vegetable crops for controlling various lepidopteran pests.

(c) Plastic clips for eggplant and tomato grafting: A small private firm "Shapla Enterprise" started to manufacture and supply small plastic clips that are needed to raise grafted seedlings of eggplant and tomato. Records show that the clip manufacturer supplied more than 250,000 clips to different organizations and farmers coming from 18 districts. This shows that the technology is spreading, though slowly, to areas outside the IPM CRSP research and demonstration sites.

The development of the above enterprises and the supplies of various IPM inputs at the farm level show that the farmers have been picking up the IPM practices in different areas and there are strong indications of gradual spread of the IPM technologies in larger farming communities in Bangladesh.

Technology Transfer of IPM Practices in Vegetable Crops through NGO Collaboration

Technology Transfer by MCC Bangladesh: In collaboration with 13 local NGOs, MCC carried out as many as 99 demonstrations on six IPM technologies in farmers' fields at 13 locations of six districts and also arranged training programs for farmers.

1. Fruit fly control in cucurbit crops by pheromone bait trapping: Ten demonstrations for bait trapping with 'cuelure' pheromone were established in six districts. The participating farmers earned 50% higher profit than those who practiced chemical control. In addition, 150 farmers adopted pheromone bait trapping in about 30 acres of cucurbit crops in Tarap sartaj village of Bogra district.

2. Organic soil amendment for management of soil-borne disease pathogens and improvement of soil health: As many as 61 demonstrations on organic soil amendments with decomposed poultry refuse, mustard oil-cake and Tricho-compost were established involving as many farmers for management of soil-borne disease pathogens and improvement of soil health. Amendment with poultry refuse in cabbage crop brought about 31% higher profit, that with mustard oil-cake in cauliflower produced 44% higher profit and the amendment with Tricho-compost in eggplant fetched 27% higher income for the farmers.

3. Manual destruction of lepidopteran caterpillars by hand-picking in cabbage crop and practice of two hand-weeding in tomato crop: Fourteen farmers participated in as many demonstrations for manual destruction of leaf-eating caterpillars of diamond back moth and *S. litura* and received 23% higher economic returns as compared to the farmers who applied pesticides.

Similarly, farmers participating in practicing two hand-weeding at the critical growth stages of tomato crop (20 and 40 days after seedling transplantation) earned 14% higher income as compared to the farmers practicing 4-5 hand-weeding as done traditionally.

Technology Transfer by Practical Action-Bangladesh (PAB): Although the FoSHoL project phased out, PAB continued the IPM technology transfer activities through their own extension programs. Moving out from Jamlapur and Faridpur areas, PAB established their project activities in Lalmanirhat and Sirajganj districts and selected some local NGOs for demonstrations of IPM technologies in farmers' fields. During 2008-2009, one of PAB's local NGO collaborators (SKUS) organized and facilitated 924 farmers in 22 villages who adopted 'cuelure' pheromone baiting for fruit fly control in about 270ha (670 acres) of cucurbit crops in Lalmanirhat district. Another local NGO (Own Village Advancement-OVA) helped eight farmers to adopt pheromone baiting for fruit fly control in a small area that reduced pesticide applications by more than 50% and fetched the farmers 25% higher income.

Nepal

B.K. Gyawali and Luke Colavito

Nepal IPM CRSP collaborates with the Department of Agriculture, Nepal Agriculture Research Council (NARC) and non-government organizations. Major constraints in quality control of pheromones and traps have been identified. Nepal IPM CRSP introduced three technologies namely mashed sweet gourd (MSG), soap-water and grafting from BARI, Bangladesh to NARC. Among them soap water traps used against fruit flies on cucurbits successfully replaced the use of the insecticide (Malathion 50% EC) in traps. For the last two years MSG technology has produced encouraging results. This technology has helped poor farmers in mass trapping of male and female both sexes of fruit flies on cucurbits. The grafting technology has also made a significant contribution in Nepal in reducing the cost of pest control in tomato and eggplant against nematode and bacterial and *Fusarium* wilt diseases. NARC scientists were successful in developing cheapest grafting chamber for $100 U.S. dollars. Similarly scientists were successful in reducing ten times the cost of grafting by using para-film in grafting as compared to imported grafting clips. A total of 68 service providers and 24 nursery growers participated in four trainings from September 27-28, 2007, June-2-3, 2008, January 8-9, 2009 and September 13-14, 2009 organized by NARC and IPM CRSP/WI. Scientists from NARC demonstrated yield difference between grafted and non-grafted plants and achieved regional standard. Pheromones developed in Nepal were cheaper and effective as compared to imported ones. Encouraging results were observed from pheromones, bio-fertilizers and bio-pesticides on-farm research in Nepal. A total of 142 farmers (45.8% women) participated in technology development and transfer of pheromones, bio-fertilizers and bio-pesticides and produced encouraging results.

Taxonomy: Identification of fruit flies from Nepal

The following fruit fly species from Nepal were identified by Indian taxonomist Dr. V.V. Ramamurthy at the Indian Agricultural Research Institute (IARI), New Delhi, India.

Bactrocera tau (Walker)	*Bactrocera scutellaris* (Bezzi)
Bactrocera cucurbitae (Coquillett)	*Bactrocera nigrofemoralis* (White & Tsuruta)
Bactrocera dorsalis (Hendel)	*Bactrocera zonata* (Saunders)
Dacus spp.	

Pheromone traps for fruit flies in cucumber and tomato crops

Evaluation of effective pheromone traps from different sources carried out in Lalitpur, Kaski, Rupendehi, Banke, and Surkhet Districts in the farmers' field.

McPhail, Delta sticky and bottle traps were compared for effectiveness in trapping the fruit flies. The lures were unchanged throughout the season. The trapped adult fruit flies were collected and recorded on every 4^{th} day.

Among the traps, bottle traps using soap water was found effective and cheapest as compared to McPhail trap and Delta sticky trap. Peak occurrence of fruit flies on cucurbits seems to be the second week of May to second week of June. Among the food lures, mashed sweet gourd was found effective and superior than the protein hydrolysate in attracting fruit flies.

Evaluation of bio-fertilizers and bio-pesticides

Bio-fertilizers and bio-pesticides are available in the local markets but their quality differs to a great extent. Some of the bio-fertilizers are specific to the targeted crops and their response and requirement differ according to crops selected.

Bio-fertilizers and bio-pesticides from local market were compared with farmer's practice (chemical fertilizers and chemical pesticides) on tomato, coffee and tea crops. Among the bio-fertilizers such as, Nitrogen fixing bacteria, *Azospirillum,* phosphorus solubilizing micro-organisms, potash mobilizing bacteria and Agri VAM were utilized to compare with farmers practice in terms of yield, cost and profit.

Recommended chemical nutrient requirement for the crops (tomato, coffee and tea) were taken as farmer's practice and bio-fertilizers for supplying the nutrients were balanced in order to compare between the two treatments on three crops. The demonstrations were replicated in five farmer's fields. The demonstrations of tomato in Kaski, coffee in Syanjga and tea in Illam districts were conducted. Five farmers in each district of Kaski, Syangja and Illam were selected for bio-fertilizers and bio-pesticide demonstration. Each farmer had 80 tomato plants of same variety and age. In coffee, each farmer had 20 plants of same variety, and age. Similarly, in tea each farmer had 20 plants of the same variety, and age.

Bio-fertilizers: Slow release of nutrients required for the sturdy growth of plants that helps the selected crop plants to tolerate against the pathogenic diseases and phytophagus insects. The selected crops yield should be higher than the chemical fertilizers applied in well managed system. Therefore, the recommended dose of compost and chemical fertilizers on tomato, coffee and tea are considered as farmers practice with equivalent doses of compost as well as bio-fertilizers such as Nitrofix-B, P sol-B, K sol-B and Agri VAM. These bio-fertilizers, each (Nitrofix-B, P sol B, K sol B and Agri VAM) with well decomposed compost in separate slots were mixed. Final mixing of compost was done.

Tomato: Each farmer with 80 plants required 86g Nitrofix to mix in 4.3kg FYM, 80g P sol B in 4kg FYM and 214g K sol B in 10.7 kg FYM respectively. Farmers applied 770g of well decomposed compost (FYM) per plant. On top of the FYM farmers applied a mixture containing bio-fertilizers (NPK) @ 240g per plant.

Tea: Each farmer with 20 plants requires 33.8g Nitrofix to mix in 1.7kg FYM, 40g P-sol-B and 2kg FYM and 120g K-sol-B in 6kg FYM respectively. The application was repeated in a second dose of bio-fertilizers 30 days after first dose was applied. Apply 9kg well decomposed compost FYM per plant. On top of the FYM apply the final mixture containing bio-fertilizers (NPK) @ 494.2g per plant.

Coffee: Each farmer with 20 plants requires 300g Nitrofix and 15kg FYM, 560g P sol-B and 28kg FYM and 760g K-sol-B and 38kg FYM respectively. The application was repeated in the second dose of bio-fertilizers 30 days after first dose was applied. Five kilograms of well decomposed compost (FYM) per plant was then applied which was followed by the final mixture containing bio-fertilizers (NPK) @ 4.13kg per plant.

Bio-pesticides: Five gram each *Trichoderma viride, T. harzianum, Pseudomonas fluorescens* and 10g *Metarhizium anisopilae* per kg of FYM were added.
Three applications of bio-hume @ of 5ml per liter of water at three critical plant growth periods were applied.

Tomato:	1. At plant establishment
	2. At flower initiation
	3. At fruit enlargement
Coffee:	1. At optimum foliage development
	2. At flower initiation
	3. At fruit enlargement
Tea:	1. At optimum foliage development
	2. After first pick of tea leaves
	3. After 15 days of second application

Bio-pesticides:

On **tomato,** the first spray included *Verticillium lecanii* @ 5g per liter of water drenched during evening hours at flower initiation stage, the second spray, *Beauveria bassiana* @ 5g per liter of water drenched during evening hours 15 days after the first spray, and the third spray, *Bacillus thuringiensis* var. *kurstaki* @ 1.5g per liter of water drenched during evening hours 15 days after the second spray.

On **coffee**, the first spray included *Azadirachtin* @ 5ml per liter of water drenched during evening hours at optimum foliage development. The second spray was Karanjin @ 2ml per liter of water drenched during evening hours 15 days after the first spray. The third spray, *B. bassiana* 5g + *M. anisopliae* 5g per liter of water drenched during evening hours 15 days after the second spray. The fourth spray, *B. bassiana* 5g + *M. anisopliae* 5g per liter of water drenched, was applied during evening hours 15 days after the third spray. The fifth spray, *B. bassiana* 5g + *M. anisopliae* 5g per liter of water drenched, was applied during evening hours 15 days after the fourth spray.

On **tea**, the first spray included *Azadirachtin* @ 5ml per liter of water drenched during evening hours at optimum foliage development. The second spray, Karanjin @ 2ml per liter of water drenched, was applied during evening hours after 15 days of first spray. The third spray, *B. bassiana* 5g + *M. anisopliae* 5g per liter of water drenched, was applied during evening hours 15 days after the second spray. The fourth spray, *B. bassiana* 5g + *M. anisopilae* 5g per liter of water drenched during evening hours 15 days after third spray. The fifth spray, *B. bassiana* 5g + *M. anisopliae* 5g per liter of water drenched during evening hours 15 days after the fourth spray.

Coffee white stem borer

Five farms with five year old coffee plants and heavily infested with coffee white stem borer in Palpa and Gulmi districts were selected for monitoring the population using pheromones placed in cross vane type traps (Figures 1 and 2). The pheromones and traps were purchased from a local supplier. The trapping of adult beetles continued for 26 weeks without interruption. Pheromones were replaced every three months and the traps after six months. The trapped beetles were collected, recorded and preserved.

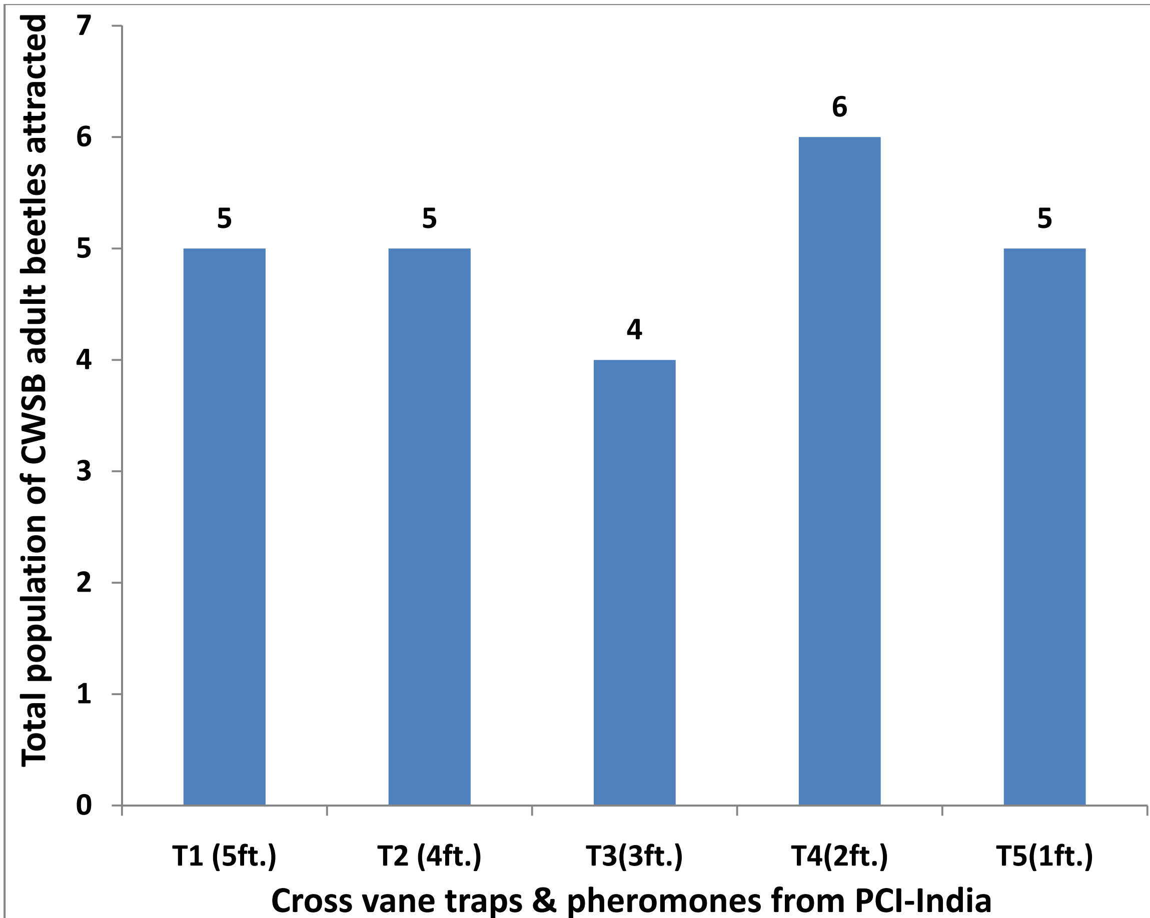


Figure 1: Effectiveness of CWSB-lures on coffee against coffee white stem borer in Palpa District, 2009 (IPM CRSP)

Effectiveness of cwsb-pheromones and cross vane traps on coffee attracted more at 2ft. height in Palpa district as compared to 5ft., 4ft., and 1ft., respectively. The pheromones and traps established at 3ft. height (T3) were found to be the lowest among the treatments in trapping adult beetles.

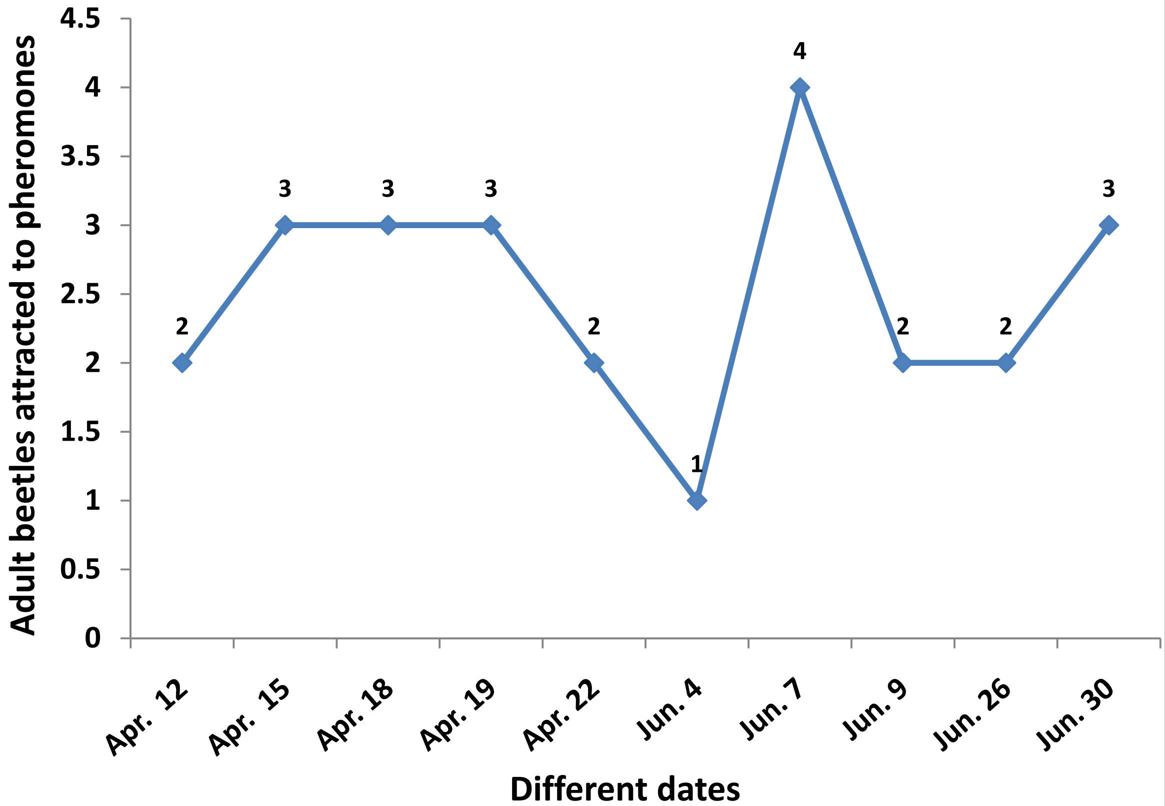


Figure 2: Peak occurance of cwsb adult beetles of coffee white stem borer in Palpa District, 2009 (IPM CRSP)

The peak occurrence of adult beetles on coffee plants was recorded during the second week of June in the Palpa district.

Performance of bio-fertilizers and bio-pesticides on tomato crop in Kaski

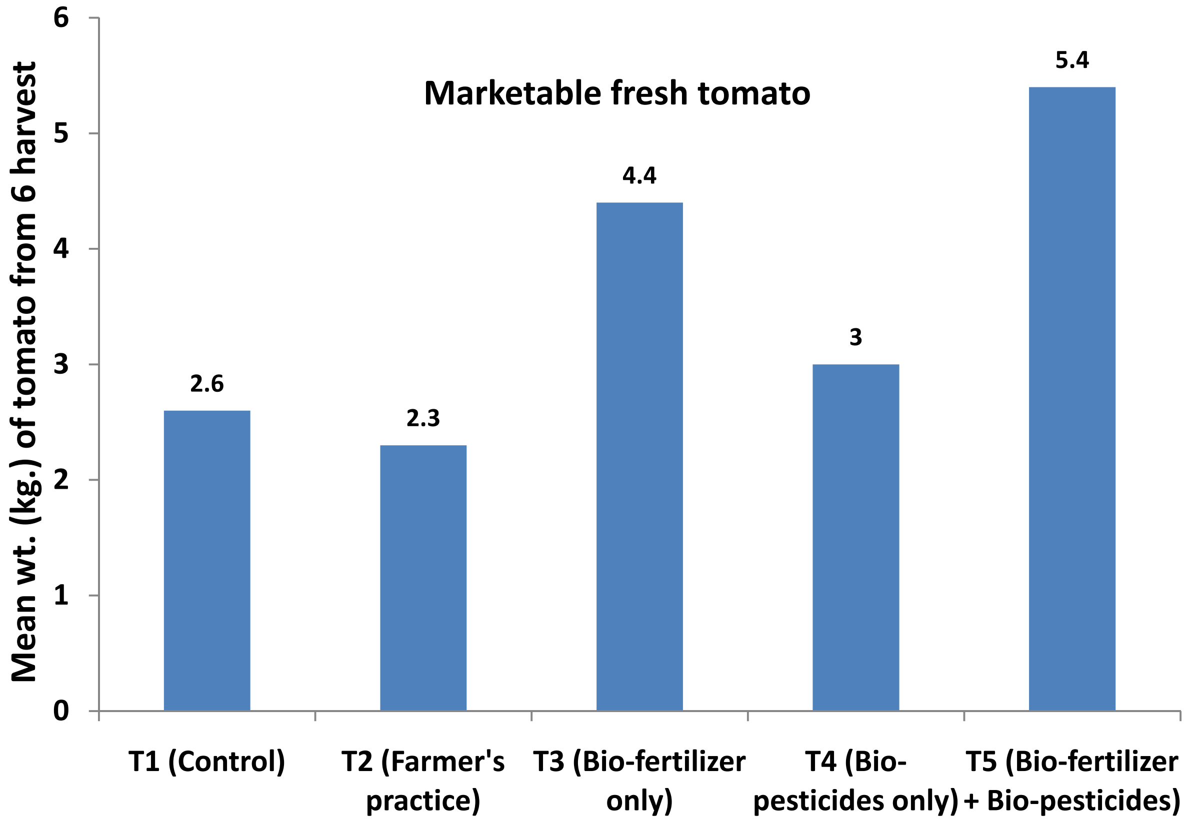


Figure 3: Effect of bio-fertilizers and bio-pesticides on tomato in Kaski District, 2009 (IPM CRSP)

Performance of bio-fertilizers and bio-pesticides (T5) on tomato produced more marketable fresh tomato till the 6th harvest followed by bio-fertilizers (T4) only, bio-pesticides (T4) only. Among farmer's practice (T2) was the lowest as compared to Control (T1) (Figure 3).

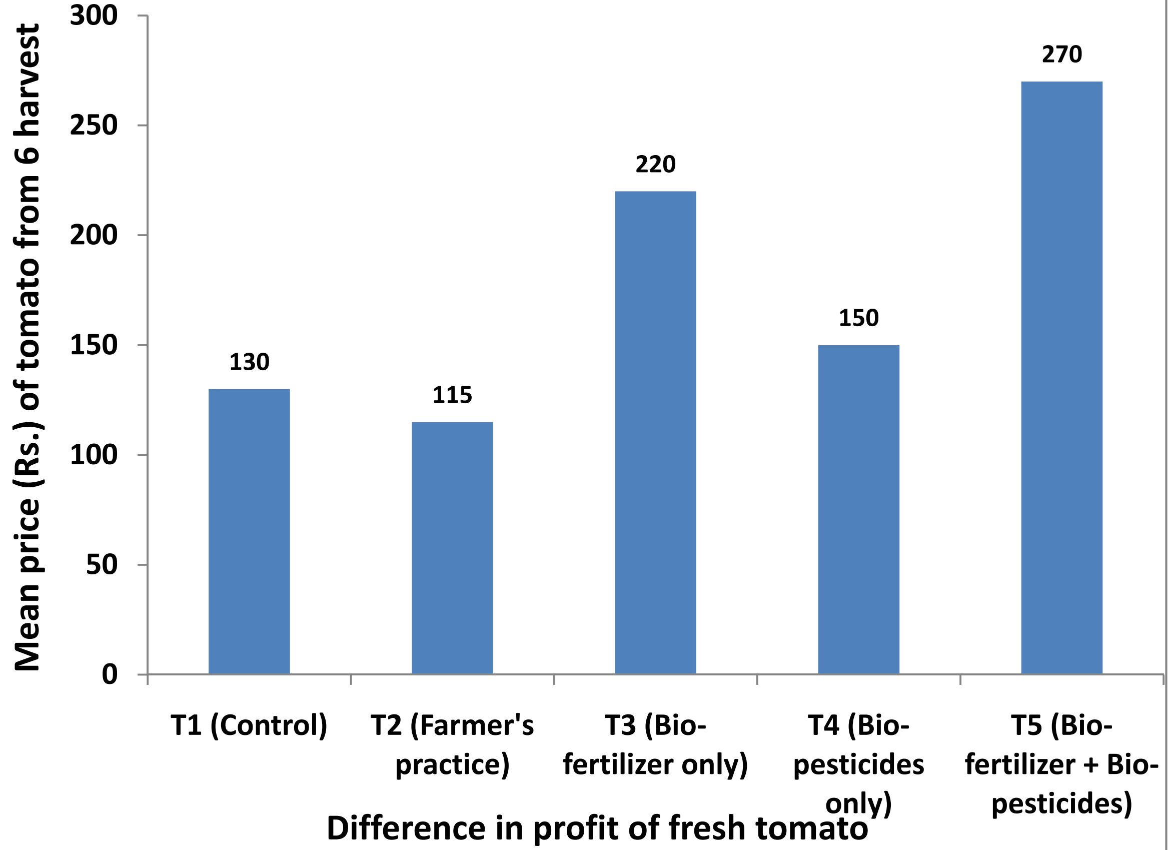


Figure 4: Difference in profit from use of bio- fertilizers and bio-pesticides on tomato in Kaski District, 2009

Similarly, the profit from use of bio-fertilizers and bio-pesticides on tomatoes in the Kaski District was proportional to the yield (Figure 4).

Marketable orthodox tea was observed at increasing trends in each picking in Illam district.

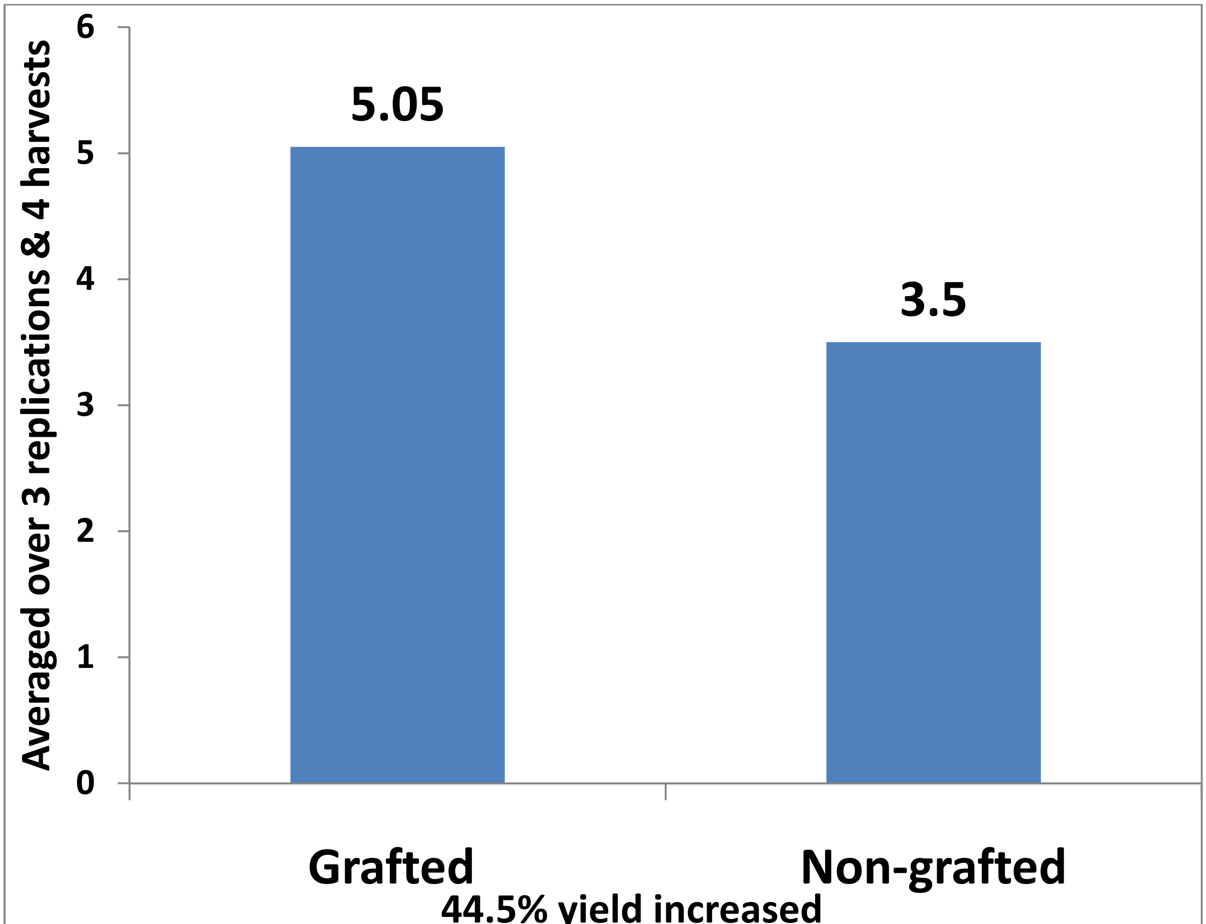


Figure 5: Performance of grafted eggplant (in kg.) at Malepatan, Kaski, 2009 (NARC/IPM CRSP)

Grafted eggplant in research station produced (44.5%) more yield than non-grafted plants (Figure 5).

India (TNAU)

V. Balasubramani, K. Angappan, V. Udayasurian, D. Sudhakar, S. Mohankumar, R. Samiyappan

Comparison of integrated management of okra with farmers practice

A trial was conducted to test verify the IPM strategies in farmer's field against the pest, disease and nematode complex in okra. The trial was laid out with the hybrid 'US 7109' in randomized block design with seven treatments and three replications.

Time of application

Pseudomonas fluorescens (10g/kg) was given as seed treatment. Neem cake (200 kg/acre) was applied in the soil at the time of last plowing. The yellow sticky bands were placed in the field, when the plants were at a height of 20cm. Three sprays of fish oil rosin soap (2 per cent) and neem seed kernel extract (5 per cent) were given 20 days after sowing and repeated on 40 and 60 DAS.

The per cent damage caused by borers and the number of sucking pests occurred during the entire cropping period were recorded. The intensity of the insect pests was recorded at 10 days interval by observing 5 plants selected at random in each replication for individual treatments. Hence totally 15 plants were observed to note the incidence of sucking pests.

The observations on percent disease incidence for *Yellow vein mosaic* virus and Percent Disease Index (PDI) for powdery mildew were recorded. The intensity of the diseases for YVM was recorded at 10 days interval by observing 15 plants selected at random in each treatment in all the replications. For foliar disease intensity of the disease was recorded in 15 leaves selected at random in each treatment following the score chart 0-9 scale and the PDI was calculated. Observations on soil population of root-knot nematode *Meloidogyne incognita* in 250cc soil was taken at 10 days interval up to 60 days and gall index at the time of termination of the field trial were recorded.

Yield was calculated based on the weight of healthy (marketable) fruits from individual treatments.

The treatments were as follows.

T_1	IPM (Seed treatment with *Pseudomonas fluorescens* (10g/kg) + Soil application of Neem Cake (200kg/acre) + Yellow Sticky Trap (1 kg/acre) + Foliar spray of Neem Seed Kernel Extract (NSKE) 5% + Foliar spray of Fish Oil Rosin Soap (FORS) 2%
T_2	IPM minus Seed treatment with *Pseudomonas fluorescens* (10g/ kg)
T_3	IPM minus Soil application of Neem cake (200 kg/ ac)
T_4	IPM minus Yellow Sticky Trap (1kg/acre)
T_5	IPM minus Neem Seed Kernel Extract (NSKE 5%)
T_6	IPM minus Fish Oil Rosin Soap (FORS 2 %)
T_7	Farmers practice

The results of various treatments on the incidence of insects, diseases and nematodes of okra are given below.

The maximum incidence of whiteflies was observed during the initial stages of the cropping period. It was higher on the 50 DAS in all the treatments. Maximum incidence of 9 per leaf on 50 and 60 DAS was recorded on the farmers plot without IPM, while there was only one per leaf on IPM plot on 30 DAS. When considering other treatments, incidence was more (8 per leaf) in treatment with IPM minus yellow sheet (Table 15). The incidence of mite was seen maximum in the later stages of the cropping period. Maximum of 21 per sq.cm was observed in the plot with farmers' practices on 50 DAS, while there were 2 per sq cm in plot with IPM practices. Considering the treatment effects, the maximum number (15/sq.cm) was observed in IPM minus fish oil rosin soap 5 % (Table 2).

The incidence of leafhopper was seen maximum in the later stages of the cropping period. Maximum of 8 per leaf was observed in the plot with farmers' practices on 40 DAS, while there were 2 per leaf in plot with IPM practices on 30, 40 and 60 DAS (Table 16).

It was observed that only yellow vein mosaic and powdery mildew were widely prevalent in the field. Yellow vein mosaic incidence was observed from 30 days after sowing where as powdery mildew incidence was observed from 40 days after sowing and both the diseases were maximum on 60 days after sowing in all the treatments. Among the treatments, IPM practices consisting of seed treatment with *P. fluorescens*, soil application of neem cake, foliar application of fish oil rosin soap (2 percent) thrice, neem seed kernel extract (5 percent) thrice and keeping yellow sticky trap were found to be very effective as it recorded only 15.33 per cent for YMV and 10.03 for powdery mildew on 60 DAS. On comparing the other treatment effects, maximum incidence of YMV (57.42 PDI) and powdery mildew (37.29 PDI) was observed in the plots where farmers practice was adopted followed by the IPM plot without fish oil rosin soap (FORS) and neem seed kernal extract (NSKE) for YMV (39.46 percent and 33.04 percent) both of which plays a major role in whiteflies management. In case of powdery mildew though the IPM plot was found to have minimum incidence, the treatment with all IPM components except *P. fluorescens* and neem cake (26.45 PDI and 24.43 PDI) recorded maximum incidence indicating that *P. fluorescens* and neem cake plays an important role in reducing the incidence of the powdery mildew (Tables 17 and 18).

There was a decline in nematode population in the IPM plots which consist of seed treatment with *P. fluorescens*, soil application of neem cake, and foliar application of fish oil rosin soap (2 percent) thrice, neem seed kernel extract (5 percent) thrice and keeping yellow sticky trap. Among the treatments, the IPM void of neem cake treatment resulted in high nematode population and the highest was in the farmer's practice (Table 6). Similarly the gall index was the lowest in IPM (3.2) as against the farmer's practice (5.2) which recorded the highest in a 1-5 scale (Table 7).

Table 15: Effect of various treatments on the incidence of whiteflies/leaf in okra US agriseeds 7109 hybrid (Kaliapuram, Coimbatore district)

S. No	Treatments	Number of whiteflies/leaf at indicated days after sowing				
		30 DAS	**40 DAS**	**50 DAS**	**60 DAS**	**Mean**
1.	IPM	1 (1.17)	2 (1.71)	3 (1.47)	2 (1.58)	2.00 (1.48)
2.	IPM minus *P. fluorescens*	2 (1.56)	3 (1.71)	4 (1.91)	1 (1.22)	2.50 (1.60)
3.	IPM minus Neem cake	3 (1.86)	3 (1.86)	4 (2.11)	3 (1.87)	3.25 (1.92)
4.	IPM minus Yellow sheet	5 (2.34)	6 (2.54)	8 (2.91)	7 (2.74)	6.50 (2.63)
5.	IPM minus NSKE 5%	3 (1.87)	4 (2.11)	4 (2.12)	3 (1.86)	3.50 (1.99)
6.	IPM minus FORS 2%	3 (1.86)	4 (2.11)	5 (2.35)	5 (2.34)	4.25 (2.16)
7.	Farmers practice	6 (2.54)	7 (2.74)	9 (3.08)	9 (3.08)	7.75 (2.86)
	CD (0.05): T=0.33, D=0.25, TxD=0.66					

Mean of five replications, Figures within are square root transformed values
DAS- Days after sowing

Table 16: Effect of various treatments on the incidence of leafhopper/leaf in okra US agriseeds 7109 hybrid

S. No	**Treatments**	**Number of leafhoppers/plant at indicated days after sowing**				
		30 DAS	**40 DAS**	**50 DAS**	**60 DAS**	**Mean**
1.	IPM	2 (1.58)	2 (1.56)	3 (1.87)	2 (1.56)	2.25 (1.64)
2.	IPM minus *P. fluorescens*	2 (1.58)	3 (1.86)	3 (1.87)	3 (1.86)	2.75 (1.79)
3.	IPM minus Neem cake	3 (1.86)	4 (2.12)	4 (2.11)	3 (1.86)	3.50 (1.98)
4.	IPM minus Yellow sheet	4 (2.12)	5 (2.34)	5 (2.35)	4 (2.12)	4.50 (2.23)
5.	IPM minus NSKE 5%	3 (1.86)	4 (2.12)	4 (2.11)	3 (1.86)	3.50 (1.98)
6.	IPM minus FORS 2%	2 (1.58)	2 (1.47)	2 (1.58)	3 (1.81)	2.25 (1.61)
7.	Farmers practice	7 (2.74)	8 (2.92)	7 (2.73)	3 (1.87)	6.25 (2.56)
	CD (0.05): T=0.20, D=0.15, TxD= 0.40					

Mean of five replications, Figures within are square root transformed values.
DAS- Days after sowing

Table 17: Soil population of root-knot nematode *M. incognita* (No./250 cc soil) under field condition in okra US agriseeds 7109 hybrid

Treatments	**10 DAS**	**20 DAS**	**30 DAS**	**40 DAS**	**50 DAS**	**60 DAS**	**Mean**
IPM	61.2 (7.82)	70.5 (8.40)	87.1 (9.33)	98.8 (9.94)	112.5 (10.61)	136.3 (11.67)	94.40 (9.63)
IPM minus *Pseudomonas fluorecens*	99.2 (9.96)	123.7 (11.12)	132 (11.49)	141.6 (11.90)	160.4 (12.66)	211 (14.53)	144.65 (11.94)
IPM minus Neem cake	116.3 (10.78)	125.6 (11.21)	131.2 (11.45)	162.9 (12.76)	184.5 (13.58)	250.8 (15.84)	161.88 (12.60)
IPM minus Yellow sticky trap	82.2 (9.07)	96.3 (9.81)	107.6 (10.37)	126.6 (11.25)	158.7 (12.60)	245.3 (15.66)	136.12 (11.46)
IPM minus NSKE	93.8 (9.68)	124 (11.14)	139.6 (11.82)	157.3 (12.54)	192.5 (13.87)	227 (15.07)	155.70 (12.35)
IPM minus FORS	85.6 (9.25)	99.7 (9.98)	124.3 (11.15)	158 (12.57)	189.2 (13.75)	220.6 (14.85)	146.23 (11.93)
Farmer's practice	115.3 (10.74)	138.6 (11.77)	167.3 (12.93)	190.5 (13.80)	234 (15.30)	268.3 (16.38)	185.67 (13.49)

Figures in parentheses are √n transformed values, CD (0.05): T- 0.01; D-0.023; T x D-0.032
DAS-Days after sowing

Yield

Considering the treatment effects, the IPM plot (14.81t/ha) was found to have maximum yield than farmers plot (6.72t/ha) (Table 8).

Table 18: Effect of different treatments on yield of okra in different hybrids

Treatments	**Yield (t/ha)**
IPM	14.81 (3.91)
IPM minus *Pseudomonas fluorecens*	8.15 (2.94)
IPM minus NSKE 5%	9.82 (3.21)
IPM minus yellow sticky trap	8.14 (2.94)
IPM minus Neem cake	9.78 (3.21)
IPM minus FORS	7.64 (2.85)
Farmer's practice	6.72 (2.68)

Figures in parentheses are √n transformed values, CD (.05) = 0.46

Genetic diversity of whitefly based on Random Amplified Polymorphic DNA-Polymerase Chain Reaction

Bemisia tabaci (Hemiptera: Aleyrodidae) is broadly polyphagous, feeding on an estimated 900 hosts. Since the early 1990's, it has caused escalating problems to economically important field, horticultural crops and ornamental plants. The taxonomy of the whitefly has long been known to be problematic because morphological traits of adults do not readily permit differentiation between genera or species.

Recently, *B. tabaci* has developed several biotypes and acts as a virulent vector of plant viruses in agricultural ecosystems owing to a combination of insecticide resistance, reduction in natural enemies and increased monoculture production of crops in subtropical and tropical areas.

To understand the genetic diversity of the *B. tabaci* species complex many specific genes are being utilized. Although much of the information is available on the biotype prevalence based on the locations and regions, molecular information on the genetic diversity of populations based on host plants is scarce.

Whiteflies were collected from four different hosts—eggplant, cotton, okra and cauliflower—in various locations of Tamil Nadu under tropical climatic conditions, except at Ooty, and were evaluated for genetic diversity using RAPD markers. RAPD-PCR has been used to differentiate *B. tabaci* variants and to estimate the genetic relationships of closely related populations from the same geographical locations. The diversity of the whitefly population was seen based on the host species. It is evident from the dendrogram, which resulted with three major clusters accommodating whitefly populations from different host plants. The major cluster A is again divided into minor clusters A_1 and A_2 representing cotton and okra host populations. The major cluster B at majority represented the whitefly population collected from eggplant and is further divided into B_1, B_2 and B_3 representing the regions. The cluster C acted differently comprising whiteflies collected from eggplant of Pudukkottai area. Since population from eggplant at Pudukkottai alone being formed into a separate cluster, it may be suspected to be reproductively isolated from population obtained from other crops or within eggplant itself. This suggests that a differentiation of populations has already occurred, mainly according to the host plant, instead of the geographical region where populations are localized. Among the biotypes of *B. tabaci,* the B biotypes, in the previous two decades has been distributed widely and caused tremendous losses worldwide as a pest and vector of virus diseases. The B biotype has distinctive biological traits, together with esterase and RAPD patterns that showed little variation.

Two thoughts are expected to arise from our present study. One may be that both A and B clusters are distinct biotypes, while C cluster may come under either A/B. On the second set, the clusters A and B may represent a single biotype whereas the cluster C may be a separate biotype. Biotype 'B' is now being present in most of south India from the original point of introduction during 1999 at Kolar district Karnataka bordering Dharmapuri district, Tamil Nadu. The rapid spread of whitefly 'B' biotype is being experienced in South India as has been observed in other parts of the world. The whitefly population from cotton is denotified as "B biotype". Therefore, it is assumed that the population obtained from cotton may be confirmed as 'B' biotype.

The whitefly population harboring cabbage has been adjudged as 'B' biotype, hence, it may be true that whitefly samples collected from cauliflower, a member of Brassicaceae family accommodating cabbage, may be a 'B' biotype. There exists population isolations based on host plants among the whitefly, *B. tabaci* population and needs further molecular analyses to understand the physiological and evolutionary relationships, which may through lights for taxonomical perspectives and pest management decisions.

Genetic diversity of eggplant fruit and shoot borer (EFSB) *Leucinodes orbonalis* based on Random Amplified Polymorphic DNA-Polymerase Chain Reaction

The eggplant, being native to India, shares 31% area (5.1 x 10^5ha) and 28% production (82 x 10^5t) of the world. Eggplant is mainly cultivated on small family farms and it is a source of cash income for resource-poor farmers. The eggplant diversity is rich in India and farmers maintain own seeds for perpetuation.

The eggplant fruit and shoot borer (EFSB) *Leucinodes orbonalis* (Lepidoptera: Pyraustidae) is considered to be the most serious pest of eggplant in Southeast Asia. The damage to fruits alone was reported to vary from 40 to 80 per cent. On eggplant, the initial damage by EFSB was confined to petioles, midribs of large leaves and auxiliary shoots and once fruits are available they are the primary food source for the pest than other plant parts. Owing to the severity of the pest damage, farmers resort for frequent and haphazard sprays of pesticides to kill the larvae. Insecticides were found to be highly effective, rapid in curative action and adaptable to most situations, but have failed in the case of hidden pests like EFSB. The susceptibility of EFSB to different insecticides is highly varying. Varied management tactics applied against EFSB have modified and resulted in heterogeneity of population. In response to the stresses, the populations of *L. orbonalis* have changed to adapt the ill-effects by changing their eco-behavioral pattern, feeding physiology and reproduction, in addition to the changes in their molecular machineries. Genetic characterization of population of insect pests plays a pivotal role in determining management strategies of the insect pest. Therefore, an attempt was made to characterize the genetic diversity among *L. orbonalis* which also included potato as its host.

Random Amplified Polymorphic DNA polymerase chain reaction (RAPD - PCR) was applied to survey the EFSB populations in Tamil Nadu, India. EFSB larvae were collected from twelve different locations of Tamil Nadu. Totally 15 primers were used and 11 primers developed polymorphic bands and yielded 49 clear bands. According to Jaccard similarity, the similarity ranged from 0.953 to 1.000. The UPGMA dendrogram yielded two clusters deduced that all the EFSB population had 100 percent similarity depicting no variation among the population, may be attributed to the host specificity of the lepidopteran.

Training workshop on integrated vegetable grafting technology for managing soil-borne diseases and increasing tolerance to flooding in the hot-wet season at Tamil Nadu Agricultural University, Coimbatore, India

The training was organized for educating the vegetable farmers about grafting for management of soil-borne diseases, especially for women farmers, who are engaged in vegetable cultivation in Tamil Nadu, India. Trainers: Deng-Lin Wu, Gregory C. Luther and E.A. "Short" Heinrichs.

A total of 35 farmers were invited, and all of them have registered and attended the training out of which eighteen farmers were women.

India (TERI)

Nutan Kaushik

Transfer of IPM Technologies for Okra, Eggplant, Tomato and Cucurbits at Uttar Pradesh, Andhra Pradesh and Karnataka

The Meerut Division of Uttar Pradesh (U.P.) has about 70% land under agriculture and 5% land under forest. The irrigated net sown area in the division is 76%. It receives, on an average 907 mm rainfall; the climate is drying sub-humid to semi-arid. Soil is loam to sandy loam. Soils are deep and water table is high. Tube wells are the main source of irrigation. Canal irrigation, tube wells, open wells and tank irrigation are also used to supplement irrigation. Agriculture is the main occupation of the rural people.

In Kolar, Karnataka and Chittoor, Andhra Predesh (A.P.) around 70% lands are dry lands. Only 30% lands are irrigated. As a part of the Eastern Ghats, most of the district is studded with hills. The districts receive rains from both monsoons. It gets about 900 mms of annual average rainfall. The salubrious climate and easy drainage of water in most areas enable the farmers to raise a variety of crops from pan and banana to sugarcane, paddy, groundnut and flowers.

Technology transfer - Following technologies were transferred to the farmers in the villages of U.P, A.P and Karnataka

The IPM demonstrations consisted of use of following technologies:

- **Use of pheromone traps and yellow sticky traps-** Pheromone technology was demonstrated to the farmers as a monitoring and mass capturing technique. It is also important to note that farmers of selected villages in above mentioned states were not aware about this technology. Yellow sticky trap technology for management of soft bodied insects were demonstrated in same villages, as a out come of this most of the farmers in these regions are now adopting these technologies as one of the low cost, effective and easily available technologies.

- **Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens*-** The effect of seed treatment with *T. viride and P. fluorescens* in plant protection was demonstrated to farmers. The demonstrations of seed treatment with *T. viride* and *P. fluorescens* in sick plots resulted up to 90% protection as compared to control (completely damaged).

- **Best ways for biopesticide spray-** Farmers were not aware about the method of biopesticide spray. Government Agriculture department distributed some Nucleo-polyhedrosis Virus (NPV) and *T. viride* among the farmers but they were not aware about the use. We demonstrated the technology for safe spray and advice to admixture of UV protectents in NPV's and *T. viride*. We also demonstrated the protective measures in case of chemical pesticide sprays.

- **Technology for production of neem spray from neem seed kernel (NSK) -** Neem, *Azadirachta* sp. is well known for its insecticidal properties. Most of the farmers were aware of use of neem as leaf extract, however, only a few had used it in the field. The technology of NSK spray from neem seed kernel was demonstrated to the farmers. The NSK spray had shown better results as compared to neem leaf extract.

- **Knowledge dissemination on biopesticides** viz., *Bacillius thuringiensis* (*Bt*), NPV, *Beauveria bassiana, Tricho-cards* (*Trichogramma sp.*). Awareness was created regarding importance of natural enemies in IPM and their conservation.

- **Field scouting:**

  Regular field scoutings were carried out during complete crop season to observe pest population in the experimental fields. The scouting data was used to determine the IPM interventions if required. Scouting method consisted of zigzag route method across the field to ensure proper coverage. Two observations per week from five randomly selected plants on damage and insect count were recorded.

Transfer of vegetable IPM technology: Socioeconomic survey of the vegetable belt of the selected villages was done too assess the current status, based on which IPM technology for following crops were designed and demonstrated:

1. Okra
2. Tomato
3. Eggplant
4. Cucurbits

A questionnaire consisting of questions on land holding, number of children, education, source of seeds, hybrids/ traditional varieties, pests and diseases, control measures, source of control measures recommendations, indigenous methods of pest control, number of pesticide application, name of pesticide, cost of pesticide, yield etc were filled from 20 farmers/ villages during survey. On the basis of data obtained following conclusions:

1. Most of the farmers have small land holding (1-2.5 acres) and are illiterate. Few are educated, up to 12th standard.

2. Small farmers are lacking farm equipments.

3. Only big farmers (>20 acres) own farm machinery like tractor, hoeing machines and power sprayers

4. Vegetable cultivation is a major agricultural activity in small plots of 1-2 acres. Vegetable cultivation is also more labor intensive than cultivation of field crops.

5. Most of the farmers use hybrid vegetable seeds.

6. Farmers are not aware about appropriate pesticides for any pest and disease. Pesticide dealers in the area remain the source of information for pest management and selection of pesticides or any field problems.

7. Farmers spray pesticides 20-25 times on vegetable crops. They do not use any type of Biopesticide for pest management except for a few farmers using neem leaf extract spray.

Demonstrations were carried out in:

I. UP state of northern India
II. AP and Karnataka states in southern India

I. Demonstrations in northern India:

The Demonstrations were started initially with four villages and then extended to eight villages of Meerut Division. The villages were Upeda, Tatarpur, Shyampur, Bhoorgarhi, Sikroda, Patana, Bagadpur, and Piplaida.

Okra IPM technology

The major yield limiting factors in okra (variety: Arka Anamika and M-10) were insects viz., Jassids, white flies, *Earias* sp. and red spider mite and diseases viz., Yellow vein mosaic, bacterial and fungal wilt and root knot nematode. Integrated pest management demonstrations started from field preparation. A group of 15-20 farmers was present at each IPM demonstration. Nematode management demonstrations were undertaken with the incorporation of *Paecilomyces* in soil @ 5 kg / acre and neem seed kernel powder @ 80 kg / acres. Seed treatment with *T. viride* and *P. fluorescens* @ 10 g/kg, resulted in protection against bacterial and fungal wilt. The sucking pest complex (white flies and jassids) management was demonstrated, consisting of the use of yellow sticky plastic sheets, neem formulation spray, *Beauveria bassiana* and the use of safer chemicals such as Thiomethoxam, Acetamiprid and Imidacloprid, if required. Fruit borers were managed by pheromone trap based mass trapping, *Bt* spray, and spray of microbial insecticide, Spinosad. Application of wettable sulfur and Propargite was found effective against red spider mite.

Table 19a: Insect pest scenario in IPM and farmers practice of okra, Kharif 09

Practice	Farmer name	Pest Incidence status					
		Jassids/ leaf	*Helicoverpa* (%)	Mites/plant	*Earias* (%)	Whiteflies/plant	Nematode (%) middle age
IPM	Mr. Pannalal	4.2	0.5	25	2.4	4.3	60 (Came at late stage of the crop)
	Mr. Surinder Kumar	4.1	0.6	30	2.4	4.5	65 (Came at late stage of the crop)
	Mr. Ramesh Chandra	4.3	0.3	25	2.0	3.2	--
	Mr. Rajkumar	5.2	0.4	32	3.0	3.5	15
	Mr. Abad	4.1	0.5	24	3.2	4.2	--
Non-IPM	Average farmer practice	8.3	2.3	35	8.2	10.2	90

Okra IPM trials were conducted on 5 different farmers fields at two different villages: Bhoorgarhi, and Patana. The nematode infestation reached a maximum population at mid picking and was considered a major yield reducing factor. Before picking, symptoms were mild with slight difference in infested points. However, two farmers, Pannalal and Suriender Kumar obtained higher yield of 5150 kg/ acre and 4422 kg/acre in spite of nematode infestations of 60 and 65 percent respectively because they came during the later stages of the crop (Table 19a and 19b). The nematode management in these two fields consisted use of *Paecilomyces* sp. *and Pseudomonas fluorescens*, which slowed down the activity of root-knot nematode and enhanced the yield.

In co-farm practice (control) the spray of Carbofuran at severe infestation could not reduce the nematode resulting 90% to 100% infestation.

The population of other pests observed in IPM demonstrations was low as compared to control.

The sucking pest complex (jassids + white flies) population varied from 3.2 to 5.2/ leaf in IPM plots while in control plots it was 8.3 to 10.2 insect/ leaf. The mites/ plants were also less as compared to control. The insect infestation (*Helicoverpa armigera* and *Earias vittala)* varied from 0.3 – 0.6 and 2.0 – 3.2 percent respectively in IPM plots as compared to control (2.3 and 8.2 percent respectively). The infestation of nematode at mid plucking in IPM and control was varied from 15 – 65 and 90 percent respectively. The above data clearly indicates that IPM practices successfully reduced the total pest complex as compared to control (Co-farm practice).

The cost benefit analysis (Table 19b) also showed that highest net profit/ acre was obtained by IPM farmer, Mr. Panna Lal (Rs. 62356) followed by Mr. Abad, Surindra, Ramesh and Rajkumar who earned Rs. 61446, 61303, 43596 and 37394 respectively following IPM practices. Whereas the net profit in control plots (Co-farm practice) was only Rs. 28112/ acre.

Table 19b: Cost economics analysis in different IPM demonstration sites of okra at U.P in Kharif 2009

Heads (Cost in Rs/Acre)	**Farmer's name**					
	Mr. Panna Lal	**Mr. Abad**	**Mr. Chandra**	**Mr. Kumar**	**Mr. Rajkumar**	**Farmer practice**
Total cost of production	9744	9744	10192	10528	10416	11088
Yield (kg)	5150	5085	3842	4422	3415	2800
Value of the product @ Rs 14/- per kg	72100	71190	53788	61831	47810	39200
Net profit	**62356**	**61446**	**43596**	**51303**	**37394**	**28112**

Tomato IPM technology-

IPM package for tomato consisted:

- Use of resistant / tolerant varieties
- Seed treatment with *T. viride* and *P. fluorescens*
- Soil treatment with neem cake
- Seedlings treatment with *T. viride* + *P. fluorescens*
- Pheromone traps for monitoring and mass trapping of *Helicoverpa armigera*
- Yellow sticky traps for monitoring and mass trapping of whiteflies, aphids, jassids
- Bio-pesticides such as neem formulation, *Bt* formulation, *Beauveria bassiana* formulation and NPV of *H. armigera*
- Need based use of green label safe pesticides – Spinosad, Imidacloprid, Acetamiprid, Propargite, and Sulfex,

Farmer practice:

- Farmers are not aware of resistance/tolerant varieties
- Seed treatment with biocontrol agents is not a regular practice; some innovative farmers do the same.
- No soil treatment, if situation demanded they give only chemical treatment phorate, carbofuran or chlorpyriphos
- Most of the farmers are not aware of pheromone traps and yellow sticky traps

Generally farmers use chemical pesticides, while few use neem leaf extract

Major insect pest:

Major pests observed were aphid (*Lipaphis sp.*) whitefly (*Bemicia tabaci*), leaf miner (*Liriomyza trifolii*), mealy bug (*Saccharicoccus sacchari*), hadda beetle (*Epilachna vigintioctopunctata*), Jassids (*Amrasca devastans*), *H. armigera*, blight (early and late), leaf curl, wilt, fruit rot, and fruit cracking.

Management of sucking insects included the use of neem spray and *Beauveria bassiana*. The chemicals viz., Acetamiprid and Thiomethoxam were used in case of utmost requirement only. Pheromone traps, NPV and Bt were the first weapons used against *H. armigera*. Blight management consisted use of combination of systemic and contact fungicides (carbendazim + mancozeb, Saaf and metalaxyl + mancozeb, Ridomil) and copper fungicide- Blitox-50. Bio-fertilizers were applied to maintain healthy plants. Vector control was achieved with the help of spraying chemical viz., Acetamiprid. Biostimulant and tri-contenal were used for good yield. Eight Pheromone traps per acre were installed for monitoring and mass trapping of *Helicoverpa armigera*. The IPM practices viz., Pheromone trap, NPV-H and *Bt* gave effective control against *H. armigera* population. Insect pest scenario of tomato field is given in Table 2a.

Tomato IPM demonstrations were carried out at six different farmer’s fields during Rabi (winter season, September to January), 2008. Pravesh Kumar, Village Tatarpur obtained maximum yield (11250 kg/ acre) with IPM package provided (Table 20b). The observation from his field also showed that polymulch effect was positive as yield from mulched plot (7135 kg) was higher as compared to unmulched plot (4115 kg). Therefore, it is concluded that additional yield was the effect of polymulch as it reduced the weed competition. The infection of leaf curl virus was one of the major yield-reducing factors during the season. It was evident to note that in control (co-farm practice) infestation was 100% while it was lowest (18 %) in Ajeet Singh’s field following IPM.

Table 20a: Insect pest scenario in IPM and farmer practices with tomato, Rabi 08

Practice	**Farmers' Name**	**Pest incidence status**							
		Whiteflies/ leaf	**Aphids/ leaf**	***Helicoverpa* (%)**	**Leaf miner/ leaf**	**Blight (%)**	**Leaf curl (%)**	**Tospo (%)**	**Fruit rot (%)**
IPM	**Mr. Devpal Singh**	2.2	0.4	1.6	4.3	8	75	15	2
	Mr. Pravesh Kumar	1.6	0	1.2	3	0.8	62	12	3
	Mr. Ajeet Singh	1.6	0.2	0.6	3.3	0.6	18	7	2
	Mr. Rajinder Singh	1.6	0.2	1.2	5	10	55	8	5
	Mr. Mahavir Singh	2.2	0.4	1	4	1	52	8	5
	Mr. Anil Kumar	2.2	0.4	1.4	4.2	12	90	20	5
Non IPM	**Farmer practice**	3.6	7.6	2.6	5.6	23	100	12	12

The cost profit analyses indicates that highest net profit were obtained by Mr. Pravesh Kumar (Rs.100908) followed by Mr. Mahavir Singh, Devpal Singh, Anil Kumar and Ajeet Singh who earned Rs. 77464, 75884, 71717 and 51303/ acre. The control plots yielded the profit of Rs. 45032/ acre only. Using IPM, Mr. Rajinder Singh obtained a net profit of Rs. 20144 due to personal problems which did not allow him to take all IPM interventions on time. Therefore, it is concluded here with this case that the appropriate time of interventions is also important for IPM success.

Table 20b. Cost economics of different IPM demonstration sites of tomato at U.P. in Rabi, 2008

Heads (Cost in Rs)	Mr. Pravesh Kumar	Mr. Anil Kumar	Mr. Mahavir Singh	Mr. Ajeet Singh	Mr. Devpal Singh	Mr. Rajinder Singh	Farmer practice
Total cost of production	11592	11616	11816	11928	11616	11056	12768
Yield (kg)	11250	8333	8928	5625	8750	3120	5780
Value of the product @ Rs 10/- per kg	112500	83333	89280	56250	87500	31200	39200
Net profit	**100908**	**71717**	**77464**	**51303**	**75884**	**20144**	**45032**

Eggplant IPM technology:

- Use of high yielding and tolerant / resistant varieties.
- Seed treatment with *Trichoderma viride* + *Pseudomonas fluorescens*.
- Soil incorporation of neem cake @ 80 kg/acre.
- Monitoring and mass trapping of *Leucinodes* with the help of pheromone traps @ 8 traps/ acre.
- Yellow sticky traps for monitoring and mass trapping of sucking pests.
- Neem, Beauveria and Bt formulation for pest management.
- Removal of affected shoots and fruits from field
- Need based spray of eco-friendly insecticides/fungicides

Farmer practice:

- Farmers are not aware about resistance/tolerant varieties
- Seed treatment is not a regular practice
- No soil treatment; if situation demanded they used only the chemical treatment phorate, carbofuran or chlorpyriphos
- Mostly farmers are not aware about pest monitoring and mass trapping using pheromone and yellow sticky traps
- Nursery raising is on a flat bed without any agro-net protection
- Farmers use chemical pesticides for plant protection, some also use neem leaf extract

The major yield limiting factors observed were whitefly (*B. tabaci*), hadda beetle (*E.vigintioctopunctata*), FSB *(L. orbonalis)* Jassids (*A. devastans*), and fruit rot. The sucking pest complex (white flies and jassids) was managed using yellow sticky traps, neem spray and *B. bassiana*. The chemicals (Acetamiprid and Thiomethoxam) were also used when required. The lepidopteran insects (*L. orbonalis, H. armigera* etc.) were managed by using pheromone traps, Bt and Spinosad.

The fruit and shoot borer, FSB (*L. orbonalis*) infestation was recorded higher in control plots (farmers practice) even after heavy pesticides spray. Shoot clipping was observed as good practice for management of FSB infestation as evident by the percent infestation level in the plots of Omkar Singh (3.4 %) and Niranjen Singh (3.2%) who followed shoot clipping compared to control plots (Co farm practice) which showed the 15.2 % infestation (Table 22a).

Niranjan Singh obtained the highest yield of 14315 Kg/ acre followed by Omkar Singh (12210kg/ acre) and Vinod Tyagi (9250 /acre) using IPM, whereas the control plot yielded only 6350 kg/ acre (Table 22b). The highest profit of Rs. 61103/ acre was also obtained in IPM trial of Mr. Niranjan Singh as compared to the control plot where profit was only Rs. 19430/ acre. The data from village Bagadpur is awaited as crop is in picking stage at this time.

Table 22a: Insect pest scenario in IPM and farmer practices with eggplant, Kharif 09

Practice	**Farmer name**	**Pest incidence status**				
		Jassids /leaf	**White flies/ leaf**	**Leucinodes (%)**	**Epilechna (Leaf damage per plant)**	**Fruit rot (%)**
IPM	Mr. Omkar Singh	2.3	2.8	3.4	3.1	4.3
	Mr. Vinod Tyagi	4.2	3.1	7.1	4.3	5.8
	Mr. Niranjan Singh	3.4	3.2	3.2	5.6	3.6
	Mr. Muninder Singh	5.2	3.6	3.6	3.6	--
Non IPM	Farmer practice	6.4	4.3	15.2	7.3	22.4

Table 22b: Cost economics in different IPM demonstration sites of eggplant at U.P in Kharif 2009

Heads (Cost in Rs/acre)	Mr. Omkar Singh	Mr. Niranjan Singh	Mr. Vinod Tyagi	Farmer practice
Total cost of production	10248	10472	10436	12320
Yield (kg)	12210	14315	9250	6350
Value of the product @ Rs 5/- per kg	61050	71575	46250	31750
Net profit	**50802**	**61103**	**35814**	**19430**

Cucurbits IPM technology:

- Use of resistant / tolerant varieties
- Seed treatment with *Trichoderma* and *Pseudomonas*
- Soil treatment with neem cake
- Pheromone traps for monitoring and mass trapping of fruit fly- *Bactocera cucurbitae*
- Yellow sticky traps for monitoring and mass trapping of sucking pests viz. whiteflies, aphids and jassids and winged form adults of leaf miners
- Bio-pesticides such as neem formulation, Bt formulation, *Beauveria* formulation
- Need-based use of safe chemicals

Major insect pest of cucurbits

Fruit fly (*B. cucurbitae*), red pumpkin beetle (*Aulocophora fovicolis*), leaf miners, whitefly, jassids, powdery mildew and mosaic were observed infesting cucurbits crop in the field.

A total of four cucurbits demonstration trials were carried out in 2 villages, Bhoorgadi and Upeda. Seeds were treated with *Trichoderma viride* and *Pseudomonas fluorescens* @ 5 g/100 g of seeds. Yellow sticky traps were installed to monitor and mass trapping of white flies, jassids and winged form of leaf minor just after germination. The pheromone traps for *B. cucurbitae* monitoring and mass trapping were installed 30days after sowing.

Pumpkin beetle was managed by spraying biopesticides viz., neem, *Beauveria bassiana* and Spinosad. Thiomethoxam were used for sucking insects if required.

Table 23a: Insect pest scenario in IPM and farmer practices re cucurbits, Kharif 09

Practice	Farmer name	Fruit fly (%)	Pumpkin beetle/ plant	Leaf miner/ leaf	White fly/ leaf	Jassids/ leaf	Powdery mildew (%)	Mosaic (%)
IPM	Mr.Pushpender Singh	6.7	2.3	5.2	2.3	2.0	1.3	12.0
	Mr.Panna Lal	4.8	3.6	4.7	1.5	1.3	2.0	20.0
	Mr.Omkar Singh	5.3	1.4	6.1	2.0	1.0	0.6	15.0
	Mr.Vinod Tyagi	6.1	2.3	5.2	3.6	2.6	0.8	17.0
Non IPM	Farmers practice	14.3	4.5	8.3	4.9	3.3	4.2	25.0

The major yield limiting factors observed were fruit flies and leaf miners but in the middle of the growing cycle mosaic also had an adverse impact and reduced yield of the crop. In some of the non-IPM farmers field 100 % of mosaic infestation was also recorded. The range of infestation of fruit fly was 4.8 % to 6.7 % in IPM trials as compared to 14.3 percent in control. Other pests infestations, such as, pumpkin beetle, leaf minor whitefly and jassids, were also less compared to the control. The disease incidence indicated the same trend (Table 23a). The cost economics indicated the higher profit in IPM trials as compared to the control. The highest profit (Rs. 47644/ acre) was earned by Mr. Omkar Singh who used IPM. It was followed by Mr. Vinod Tyagi, Pushpender Singh and Panna Lal who received Rs. 41250, 36562 and 33630 as net profit/ acre as compared to control where net profit was only Rs. 30222/ acre (Table 23b).

Table 23b: Cost economics in different IPM demonstration sites of cucurbits at U.P in Kharif 2009

Heads (Rs/Acre)	**Mr. Pushpender Singh**	**Mr. Panna Lal**	**Mr. Omkar Singh**	**Mr. Vinod Tyagi**	**Farmer practice**
Total cost of production	5768	5880	5606	5544	6048
Yield (kg)	2822	2634	3550	3120	2418
Value of the product @ Rs 15/- per kg	42330	39510	53250	46800	36270
Net profit	**36562**	**33630**	**47644**	**41250**	**30222**

South India, IPM demonstration

IPM demonstrations were carried out at 3 villages in A.P and 3 villages in Karnataka in southern India.

A total of 11 demonstrations were carried out to promote IPM activities among the farmers during 2008-09. The same IPM package which was implemented in northern India was effective in southern India with slight modifications to the spray schedule

Okra IPM Technology:

- Use of resistant / tolerant varieties
- Seed treatment with *Trichoderma* and *Pseudomonas*
- Soil treatment with Neem cake
- Pheromone traps for monitoring and mass trapping of *Earias vittella*
- Yellow sticky traps for monitoring and mass trapping of Whiteflies, Aphids, jassids and adults of leaf miners
- Notching of infected shoots
- Bio-pesticides such as neem formulation, Bt formulation, and Beauveria formulation
- Use of *Trichoderma* and *Pseudomonas* as foliar spray
- Need based use of green label safe pesticides

Major insect-pests causing considerable damage to okra crop were whitefly (*B. tabaci*), jassids (*A. devastans*), aphids (*L. erysimi*), thrips (*Thrips tabaci*), and mealybugs (*Saccharicoccus saccharum*) as sucking pests. The chewing insect complex included the insects (*S. litura*, *E. vittella, H. armigera* and *Mylabris pustulatta*). Major diseases causing losses in okra fields were, YMV, root rot, wilt, powdery mildew and nematode causing diseases.

In these villages, none of the farmers were cultivating okra because laborers willing to harvest the itchy crop are hard to find. We demonstrated two field trials with improved harvest technique in which heavy rubber gloves were provided for easy picking.

Three okra demonstrations each in Hanumanthnagar and Gudipalli villages were carried out in winter season 2009. It is clear from Table 5a that whitefly populations ranged from 2.5 – 5.0/leaf in IPM plots as compared to non IPM 5.6 insect/ plot. *Erias vittella* infestation ranged from 2.0 to 5.2 percent in IPM plots as compared to 15.3 % in the control. The leaf miner showed the infestation up to 5.0 leaf miner/ leaf in IPM plots whereas it was 5.6 leaf miner/ leaf in non IPM plots (Table 5a). The diseases, powdery mildew (PM), YMV and fruit rot (FR) affected yield significantly. The maximum disease severity of PM, YMV and FR in IPM plots was recorded as 8%, 20 % and 15 % respectively in IPM plots whereas the same diseases (powdery mildew (PM), YMV and fruit rot (FR)) showed 23%, 100 % and 20 % infection severity in control plots respectively (Table 24a).

Both yield and income were higher in IPM trials compared to co-farm practice. The highest yield of 2100 kg/ acre was obtained by Mr. Elumalai at Gudipalli who received Rs. 36000.00/ acre. This was followed by Mr. Kumar and Mr. Sarvana who received Rs. 32000 and 8000 respectively from the yield of 1975 kg and 1000 kg / acre respectively. Income from IPM trials was also greater compared to the control (co-farm Practice) (Table 24b).

Table 24a: Insect pest scenario in IPM and farmers practice of okra, winter 09

IPM	**Whitefly**	**Earias**	**Leaf miner**	**Powdery mildew (%)**	**YMV (%)**	**Fruit rot (%)**
Mr. Elumalai	5.0	2.0	2.3	5	18	10
Mr. Saravana	2.5	5.2	5	8	20	15
Mr. Kumar	3.0	4.1	5	00	15	10
Farmer practice	5.6	15.3	5.6	23	100	20

Table 24b: Yield and income from IPM practices of okra in winter season 09

Farmer name	Village	Yield/acre	Income	Income from his own practice
Mr. Elumalai	Gudipalli	2100 kg	36000.00	15000.00
Mr. Sarvana	Hanumanthnagar	1000 kg	8000.00	5000.00
Mr. Kumar	Hanumanthnagar	1975 kg	32000.00	16000.00

Tomato IPM Technology

- Use of resistant / tolerant varieties
- Seed treatment with *Trichoderma* and *Pseudomonas*
- Soil treatment with neem cake
- Seedlings treatment with *Trichoderma* + *Pseudomonas*
- Pheromone traps for monitoring and mass trapping of *Helicoverpa armigera*
- Yellow sticky traps for monitoring and mass trapping of Whiteflies, Aphids, jassids and adults of Liriomyza
- Bio-pesticides such as neem formulation, Bt formulation, Beauveria formulation and NPV for Helicoverpa
- Need-based use of green label safe pesticides

Major pests

Major pests (insects and diseases) associated with tomato were whitefly (*B. tabaci*), leaf miner (*L. trifolii*), Hadda beetle (*E.vigintioctopunctata*), jassids (*Amrasca devastans*), fruit borer (*H. armigera*), blight (early and late), leaf curl, wilt (*Fusarium* sp.), and fruit rot in southern India.

Five tomato demonstration trials were carried out in winter 2009 and 7 tomato trials in summer 2009. During summer trials, it was recorded that whitefly showed higher populations of 5.0/ leaf in IPM trials compared to 8.0 whiteflies/ leaf in control plots. Other insect pests and diseases were also recorded (data presented in Table 25a). IPM trials consistently yielded more income in comparison to control plots (Table 25b and 25c). Mr. Sarvana harvested the highest yield of 5.20 ton/ acre and earned Rs. 41000.00 from his crop.

In winter trials, three farmers earned >1 lakhs (Table 25c.) despite that they had never earned more than Rs. 80000.00 from the same piece of land with their own practice (Table 25c). The highest yield of 12 tons/ acre was harvested by Mr. Thimmarayar who received Rs. 155000.00 while from his own practice he received only Rs. 80000.00/acre (Table 25c).

In summer, Mr. Sarvana got 41000.00 from IPM tomato trials. It was the first time he had ever grown tomatoes. Mr. Kumar got 35000.00 Rs from the trial. He had received 20000.00 earlier from his own practice. (Table 25b)

Table 25a: Insect pest scenario in IPM and farmer practices re tomato, Summer 09

Mention units per leaf or plant or fruit or total plant PM	**White-flies/ leaf**	***Helico-verpa***	**Leaf miner**	**Blight (%)**	**Leaf curl (%)**	**Tospo (%)**	**Fruit rot (%)**
Mr. Venkatachalapathy	1.2	2.0	2.3	5	40	12	6
Mr. Lokesh Reddy	2.5	00	5	8	35	10	5
Mr. Thimmareddy	1.0	00	5	00	20	12	0
Mr. C. Vekateshappa	00	1.0	4	00	25	10	0
Mr. Sadappa	5.0	2.0	5	2.5	45	12	6
Mr. Muniraju	2.0	5.0	5	3.5	50	10	5
Mr. Krishnamurthy	00	1.0	4	00	25	10	35
Farmer practice	8.0	5.0	5	3.5	50	10	25

Table 25b: Yield and income from IPM practices of tomato in summer season 2009

Farmer	Village	Yield (Tons/acre)	Income (Rs)	Income from his own practice (Rs.)
Mr.Kumar	Hanumanthnagar	6.6 tons	35000.00	20000.00
Mr.Chandraraju	Hanumanthnagar	4.5 tons	36000.00	15000.00
Mr.Sarvana	Hanumanthnagar	5.2 tons	41000.00	First time
Mr.Vishwanath	Hanumanthnagar	3.0 tons	20000.00	12000.00
Mr.Ramareddy	Ananthpuram	3.3 tons	17500.00	10000.00

Table 25c: Yield and income from IPM practices of tomato in summer winter 2009

Farmer name	Village	Yield (Tons/acre)	Income (Rs)	Income from his own practice (Rs.)
Mr.Lokesh reddy	B.Gowdenour	10.0	130000.00	80000.00
Mr.Thimmarayar	B.Gowdenour	12.0	155000.00	80000.00
Mr.C. Venketeshappa	B.Gowdenour	7.0	110000.00	40000.00
Mr.Sadappa	Bonahalli	8.0	90000.00	50000.00
Mr.Maniraja	Bonahalli	2.7	35000.00	50000.00
Mr.Krishanappa	Bonahalli	8.0	90000.00	50000.00
Mr.Elumalai	Gudipalli	3.5	32750.00	30000.00

Impact of IPM practices:

IPM practice proved better than current farmers practice in all respects of yield, quality, environmental impact and price of the commodity, and helped to reduce pesticide usage 40-60%. (Table 26). The IPM crop fetched 1.5-3 times more money in the market than the non-IPM produce. Enhanced income is being utilized by farmers on children's education and housing construction. Farmers reported better tasting food with IPM crops.

Table 26: Reduction in pesticide sprays with IPM practices

Crop	Average no of sprays		% Reduction
	IPM	Non-IPM	
Okra	9	15	40
Eggplant	9	18	50
Tomato	8	20	60

Farmer field days

Field day and farmer's meetings on IPM practice for vegetable crops were organized by TERI, N. Delhi at Upeda village near Babugarh Cant, Hapur on 8.6.09 at Mr. Niranjan Tyagi's brinjal field. Scientists from AVRDC, Taiwan; NCIPM, India; TERI and PCI staff briefed farmers about the various aspects of safe practices of pest management. More than 70 farmers of Upeda and nearby villages (60 male and 10 female) participated in the meeting. Media Representative from Hindi daily new papers Dainik Jagran and Amar Ujala were also present in the meeting for dissemination of the information to wider public.

Training, education and capacity building

- Demonstration of IPM practices on vegetable crops at farmer fields in 8 villages in UP, 3 villages in AP, and 3 villages in Karnataka. Targeted farmer populations in these villages are nearly 80,000 including women farmers.
- 40 group meetings were held.
- One farmer meeting and many field days were organized.

We have provided trainings to the farmers on below mentioned aspects:

1. Incorporation of neem cakes and *Poicilomyces* in soil for management of soil-borne problems
2. Seed treatment effect of *Trichoderma* and *Pseudomonas*
3. Protective measures during biopesticides / pesticide sprays
4. Biopesticide spray techniques
5. Infected shoot and fruit clipping for management of egg plant FSB
6. Nursery management techniques
7. Mulching techniques in tomato
8. Neem spray making with neem seed kernels

Publications and presentations

1. Press coverage: 3 + 1
2. Paper presented at Annual Meeting of Phytopathological Society of America, Portland, Oregon, USA
3. Poster presented at 5th international Conference on Biopesticides, New Delhi.

Ecologically-Based Participatory IPM for Southeast Asia

Michael Hammig, Clemson University

Identification of a new virus disease of yardlong bean and studies of its development

Yardlong bean (*Vigna unguiculata sesquipedalis*) is extensively cultivated in Indonesia for consumption as a green vegetable. During the 2008 season, a severe outbreak of a virus-like disease occurred in yardlong beans grown in farmers' fields in Bogor, Bekasi, Subang, Indramayu and Cirebon of West Java, in Tanggerang of Banten and in Pekalongan and Muntilan of Central Java. The leaves of symptomatic plants showed severe mosaic to bright yellow mosaic and vein-clearing symptoms and pods produced by these plants were deformed with mosaic symptoms on the surface (Figure 1). Trifoliate leaves of young seedlings (10-14 day old) showed bright chlorotic spots and bright yellow mosaic symptoms. In the cultivar 777, vein-clearing was observed conferring a netting pattern on symptomatic leaves. As the season advanced, leaves of infected plants showed bright yellow mosaic symptoms (Figure 2) followed by necrosis and death of infected plants. In the Bogor area, very severe yellow mosaic symptoms were observed on cultivar 777. The disease incidence was upwards of 80%, resulting in 100% yield loss. Lab-based research, in collaboration with the Global Theme on Insect-transmitted Viruses (Dr. Naidu Rayapati), revealed the presence of *Bean common mosaic virus* (BCMV) in samples from symptomatic plants of yardlong beans.

Figure 1: Yardlong bean field with severe virus infection

Figure 2: Leaves showing bright yellow symptoms

Development of the disease in the field was monitored twice a week in an unsprayed yardlong bean field (600 m2), by counting number of plants with yellow mosaic symptoms. Five yellow pan traps were installed in the field to monitor aphid populations.

Plants with yellow virus symptoms were found as early as 14 days after planting, indicating that viruses can be transmitted through seeds. Number of plants infected with viruses increased sharply starting from day 20 until 50 (Figure 3). Further increase of virus infection was believed to be assisted by insect vectors. Aphids trapped on yellow pan trap during early plant growth (2 weeks old) consisted of *Aphis glycines* (64.7 %), *Rophalosipum* sp. (32.7 %), and *Pentalonia nigronervosa* (2.6 %).

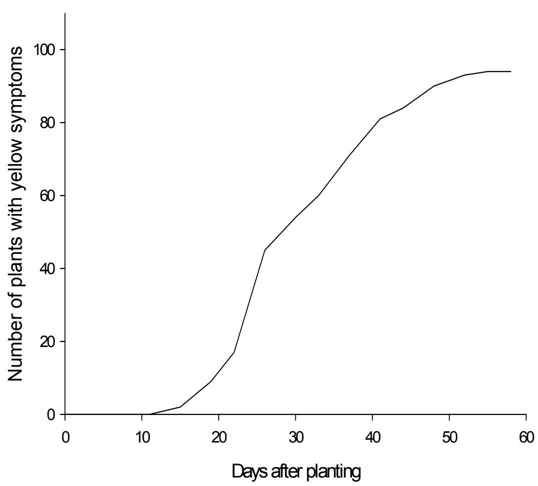


Figure 3: Exponential increase of plants infected by virus

Monitoring banana weevils by pheromone-based traps

The banana weevil, *Cosmopolites sordidus* (Coleoptera: Curculionidae), is one of the major insect pests of banana in Indonesia. The damage is caused by the larvae that feed within the corm. Pheromone traps have been used to monitor populations of this pest in various countries. A study was conducted in Cugenang-Cianjur to monitor the banana weevil population by pheromone-based traps.

The ramp trap used was obtained from ChemTica Internacional S.A. (Costa Rica). It was made of yellow durable polyvinyl chloride (PVC) and consisted of two box-shaped components, each 14 cm wide by 4 cm high (inside dimensions). Four sloping ramps led from the four cardinal directions into the sides of the lower boxes. Each ramp was 4 cm high, 13 cm long, and 12 cm wide, and slid into a slot in the bottom box component. Water with concentrated dishwashing liquid detergent (1-3%) was poured into the bottom container to retain adults that walked into the traps.

Pheromone lures (Cosmolure), sealed in a polymer membrane release device, were also obtained from ChemTica Internacional S.A. The lure packs, each containing 90 mg of pheromone, were stored at 4°C until use. Lures were hung on a wire shaped into a hook which was inserted (2 cm) through a hole on the top side of the trap.

Five traps were placed at randomly chosen locations about 200 m apart on the ground of banana plantations in two sub-villages of Kabandungan (Field A, less-managed) and Selamuncang (Field B, well-managed) separated by about 1 km. Every week during this experiment, the banana root weevils within the traps were removed and counted. The traps were then washed and rinsed, and new soapy water was added. The experiment was conducted during February-March 2009, representing the rainy season.

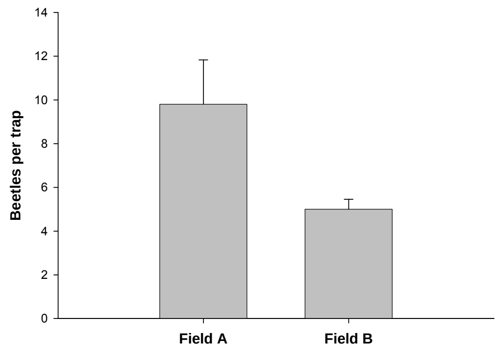


Figure 4: Number of banana weevils caught in pheromone-based traps during the rainy season.

Our field trial showed that Indonesian populations of *C. sordidus* are attracted to Cosmolure. Additionally, pheromone-baited traps caught more weevils in the less-managed field (Field A) as compared to the well-managed field (Field B) (Figure 4), indicating that sanitation, or removing old banana stumps, is an important IPM tactic for suppressing weevil infestations during periods of high moisture.

These results were supported in field trials conducted during the dry season (July-August 2009) as well, although pheromone traps in both managed and unmanaged fields contained fewer weevils, indicating that weevil populations weren't as high during the dry season as they were during the rainy season.

Field testing of sex pheromone traps of *Helicoverpa armigera* and *Spodoptera litura* (Lepidoptera: Noctuidae)

The pheromone traps of *H. armigera* and *S. litura* were produced by Pest Control Pvt. Ltd. PCI, Division: Bio-Control Research Laboratories (BCRL)-India. Six pheromone traps for *H. armigera* were tested in tomato fields, and six traps for *S. litura* were tested in taro fields. Both experiments were carried out in Cugenang during 15 June to 1 July 2009. The number of moths caught in the traps made for *S. litura (18)* was significantly higher than that caught in the traps made for *H. armigera* (2). A reduction of captured insects in *Helicoverpa* traps might be due to a lower population density in that particular area at that time. Taro patches usually harbor a good number of *Spodoptera,* which is possibly why more insects were found in *Spodoptera* traps.

Papaya mealybug, a newly introduced pest

Papaya mealybug (PMB), *Paracoccus marginatus* (Hemiptera: Pseudococcidae) is native to Mexico. It was first reported as a pest of papaya in St. Martin Island in the Caribbean in 1995 and by 2000 it had spread to 13 countries in the Caribbean, Florida in the U.S. and three countries each in Central and South America. In early 2002, it was observed on the island of Guam in the Pacific and subsequently in Palau in 2003 and in Hawaii in 2005. In May 2008, a team of scientists from the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) were carrying out surveys in Bogor, Indonesia, when they found a papaya tree infested with the mealybug (Figure5) at the Bogor

Botanical Gardens. Subsequent surveys revealed that thousands of papaya trees in the sub-district of Sukaraja-Bogor were heavily infested by the papaya mealybugs.

Infestations of PMB occur along the veins of older leaves and on all parts of young leaves and fruits. Older leaves with PMB infestations turn yellow, dry up and are shed prematurely. Tender leaves become crinkled and curly. Flowers and young fruits drop and shoots become bunchy. Honeydew excreted by this mealybug results in the development of sooty mold that covers leaves, fruits and stems. Papaya trees die within a few months after infestation.

Figure 5: Papaya heavily infested by the new invasive pest *Paracoccus marginatus*

The recent establishment of papaya mealybug in Bogor is of serious concern because this is the first report of its occurrence in Indonesia as well as in Asia. The pest will certainly spread to the rest of Indonesia and other countries in the region. Currently we are conducting surveys to identify the extent of spread, the plant species infested, and natural enemies associated with it. Surveys indicated that it has infested papaya fields in the vicinity of Bogor including Jakarta, Tanggerang, Sukabumi, and Cianjur. Recently it has spread to several locations in Central Java, Bali, and Sumatera. The papaya mealybug is a polyphagous pest. In Indonesia, other than papaya, the pest also caused heavy infestation on cassava and *Jatropha curcas*. An entomophagous fungus tentatively identified as *Neozygites* sp. has been observed in many samples of the papaya mealybug. Predaceous insects found on plants infested by the papaya mealybug in Bogor include several species of coccinellids (*Cryptolaemus montrouzieri, Curinus coeruleus, Scymnus* sp.) and larvae of *Crysoperla* sp. and a syrphid. An encyrtid species was found to be associated with the mealybug infested leaves. However, the role of local natural enemies in suppressing the papaya mealybug still has to be determined.

Since the papaya mealybug is an exotic pest, we are in process of developing a classical biological control program against it. Three species of parasitoids are being considered for importation into Indonesia. These are *Anagyrus loecki*, *Acerophagous papayae*, and *Pseudleptomastrix mexicana* (Hymenoptera: Encyrtidae).

Survey of pests and diseases in selected fruit crops

Surveys of insect pests, plant diseases, and insect natural enemies associated with banana, mangosteen, papaya, guava, and other fruits are being conducted. Samples of plant diseases were collected and sent to the laboratory for isolation and identification, and insect pests and their damage were observed directly in the field.

Major plant diseases found on banana were fusarium and bacterial wilt caused by *Fusarium oxysporum* f. sp. *cubense* and *Ralstonia solanacearum*, respectively, while the major insect pests were banana weevil, *Cosmopolites sordidus,* and a newly recognized hispid beetle. Guava fruits were heavily infested by *Bactrocera* spp. (Tephretidae). The major pest of papaya was the mealybug *Paracoccus marginatus* and the most important disease was die back caused by *Erwinia papayae* (tentative identification). On mangosteen, the major pests was a thrips (possibly *Selenothrips* sp.) which damaged the developing fruit skin leaving a brown rusty appearance on the fruit; and the disease gummosis (yellow exudate on fruits) caused by a physiological disorder. Major pests of star fruit were the fruitflies, *Bactrocera* spp, fruit borer, *Cryptophlebia* sp. (Tortricidae) and the flower moth *Diacrotricha fasciola* Zeller (Pterophoridae).

Efficacy of several botanical UV protectants for SeNPV

This study is a part of Samsudin's graduate research at IPB. Several substances such as yambean (*Pachyrhizus erosus*) filtrate, molasses, green tea filtrate and turmeric (*Curcuma longa*) filtrate were tested as UV protectant for SeNPV. Each 10 ml of SeNPV polyhedral inclusion body (PIB) suspension was mixed with 0.1 ml of each filtrate and exposed to sunlight for 30 minutes (12.30 – 13.00 pm). As controls, SeNPV without UV protectant filtrate was used.

Three drops of each mixture and control of SeNPV PIBs suspension were applied and spread evenly on the surface of artificial diet in a cup and exposed to sunlight for 30 minutes. After sunlight exposure, one larva of *Spodoptera exigua* were placed in each cup and cups were stored in a shaded area and observed for larval mortality. The results of this experiment were compared with exposed and unexposed SeNPV PIBs without the UV protectants.

After seven days, larval mortality on SeNPV mixed with yambean extract was the highest (48,998% b), followed by turmeric extract (41.77% bc), molasses (36.77 % bcd) and green tea filtrate (22.99% cde), whereas unexposed SeNPV showed 71.11 % (a) mortality and exposed SeNPV showed 4.76% g mortality.

Farmer field laboratories

In partnership with local farmers and extension agents, the IPM CRSP Team at IPB has established three new farmer laboratories (posyantis) making a total of six laboratories, located in three sub-districts (Cipanas, Cugenang, Sukaresmi). The laboratories were involved in production of microbial control agents, botanical insecticides, organic fertilizers, and composts. These materials are packaged and sold to local farmers (Figure 6). They are even being marketed in other locations in Indonesia including North Sumatra and 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. Some of the laboratories are also beginning production of two species of endophytic bacteria, *Bacillus subtilis*, and *Pseudomonas fluorescens*.

Figure 6: Bioagents and botanical insecticides produced by Posyantis

Farmer training on mass-production of *Trichoderma*

Training on mass-production of *Trichoderma harzianum* was conducted in five farmer groups during May-August 2009 (Table 1, 2, 3). There were 119 farmers, consisting of 76 males and 43 females, who participated in the training. The topics of training included preparation of corn media, putting media into plastic bags, hand and apparatus sterilization techniques, and inoculating media with hypae of *Trichoderma*. Most of the participants were very enthusiastic about the topics and were expecting to have more training on other subjects.

Table 1: Training on mass production of *Trichoderma harzianum*

Farmer Groups	Villages	Dates	Participants	
			Male	Female
Intisari	Cikanyere	08 May 2009	15	10
Agro Segar	Sindangjaya	26 May 2009	19	4
Megah	Sukatani	09 June 2009	7	9
Sinar Tani	Bantarsari	29 June 2009	16	14
Multitani Jayagiri	Cipendawa	04 August 2009	19	6

Table 2: Budget analysis of IPM and farmer practice (Farmer: Pak Ayep Hidayat)

Items	IPM	Farmer
Yield (kg)	491	510
Price (Rp.)	4,000	4,000
Gross Income	1,964,000	2,040,000
Material Costs		
Seeds	120,000	120,000
Lime	30,000	60,000
Animal Manures	-	400,000
Bokashi	120,000	-
Synthetic fertilizers (ZA,SP, KCl, NPK, foliar)	74,000	294,000
Synthetic pesticides (Dursban, Profile)	-	270,000
Service Costs		
Land preparation and cultivation	400,000	400,000
Preparation of bokashi, botanical pesticide, biotic agents	80,000	-
Total Costs	824,000	1,544,000
Net Income	1,140,000	496,000
B/C Ratio	2.38	1.32

Table 3: Budget analysis of IPM and farmer practice (Farmer: Pak Aopudin)

Items	**IPM**	**Farmer**
Yield (kg)	336	340
Price (Rp.)	5,000	5,000
Gross Income	1,680,000	1,700,000
Material Costs		
Seeds	120,000	120,000
Lime	30,000	60,000
Animal Manures	-	400,000
Bokashi	120,000	-
Synthetic fertilizers (ZA,SP, KCl, NPK, foliar)	-	200,000
Synthetic pesticides (Smack, Decis, Dithane)	-	288,000
Service Costs		
Land preparation and cultivation	400,000	400,000
Preparation of bokashi, botanical pesticide, biotic agents	80,000	-
Total Costs	750,000	1,468,000
Net Income	930,000	232,000
B/C Ratio	2.24	1.16

Support from local governments

The establishment of posyantis in the villages, an activity funded by IPM-CRSP, has stimulated district and provincial governments to allocate funding for promoting farmer group activities. Posyanti Capung in Cimacan has received Rp. 35 million ($3,500) from the district government to build a permanent compost house (3 m x 6 m), while the provincial government has provided a compost shredder to the posyanti. A much higher support of Rp. 90 million ($10,000) was given to Posyanti Agro Segar in Sindangjaya by district government to build a larger compost house (8 m x 12 m) with required equipment.

Networking

Networking is accomplished through institutional collaboration with the Agricultural Extension Agency of District of Cianjur, Food and Horticultural Crop Protection Center of West Java (BPTPH), and Directorate of Horticultural Crop Protection (Ditlin) of the Ministry of Agriculture. Dr. Aunu Rauf was invited by BPTPH to give a seminar on IPM in horticultural crops in Bandung on 22 December 2008. The participants of the seminar were pest observers coming from most of the districts in West Java. He was also a resource person for the Ditlin, especially in regard to horticultural pests and their management. Other collaboration is made with Lembaga Pertanian Sehat (LPS), an NGO supported by the national newspaper Republika.

National research grant awards

The IPM CRSP Team at IPB has written several proposals to leverage funds from national sources. Two research proposals have been funded for the fiscal year of 2009. The first is about developing biological control for papaya mealybug using local natural enemies, which is financially ($7,000) supported by the Directorate General of Higher Education. The second proposal, funded ($12,000) by Office of the Ministry of Research and Technology, is concerned with dissemination of biocontrol technology to vegetable farmers.

Management of pests of potato in North Sulawesi

A local strain of *Trichoderma* sp was isolated from soils at Modoinding, North Sulawesi, Indonesia and was identified as *Trichoderma koningii*. The effect of mixtures of different concentrations of *T. koningii* with organic material (chicken manure), sizes of potato tuber seed material and seed treatments on the populations of insects, predators and diseases and yield of two varieties of potatoes, Granola and SuperJohn (local variety) were studied at the vegetable growing area in Modoinding, North Sulawesi. Studies showed that sizes of potato seedlings, application mixture of *T. koningii* and chicken manures, treatment or without treatment of seedlings with fungicides did not give significant differences in population densities of insect pests, predators, plant disease incidence, and yield of the two potato varieties, Granola and Super John (local). However, this study indicated that the bigger potato tuber seedlings and the higher concentration of *T. koningii* added to the chicken manure, the lower the population densities of the pests, the lower the incidence of crop diseases (potato wilt), and the higher the yield of potato although it was not statistically significant.

The main insect pests found in this study on potato crops in both varieties were, *Empoasca fabae, Pthorimaea opercula, Myzus percicae, Agrotis ipsilon, Epilachna sparsa,* and *Gryllotalpha africana* and the most important predators found were *Chilomenes* sp. and *Paederus* sp. The main diseases found on potatoes were bacterial disease, *Ralstonia solanacearum*, fungal diseases *Fusarium oxyspoum* and *Alternaria solani.*

Effect of *Metarhizium anisopliae* on cabbage insects

A local strain of *Metarhizium anisopliae* isolated from *Crocidolomia pavanona* on cabbage at Rurukan in 2007 was multiplied under laboratory conditions using corn and rice. Laboratory and field tests, carried out in 2007, showed that this strain infected and killed larvae of various pests including *P lutella xylostella* and *C. binotalis* very effectively. This strain was retested in the field as a biological control for the two of the most important pests of cabbage, *P. xylostella* and *Crocidolomia binoltalis* on cabbage crops at Rurukan, Tomohon, N. Sulawesi. The study showed that the plots treated with *M. anisopliae* were on par with plots treated with insecticides.

Comparisons of populations of insect pests and incidence of tomato wilt with and without insecticide sprayings on tomato

Six lines of tomato from AVRDC and four local varieties of tomatoes were studied to evaluate their effect on the population of insect pests and the incidence of tomato wilt on each line and variety of tomato crops planted on blocks with and without insecticide spraying at Toure, Tompaso, N. Sulawesi. The study showed that the main insect pests recorded in blocks with insecticide spraying were *Liriomyza sativae, Nisidocoris tenuis, Bemisia tabaci, Aphis sp.,* and *Bactocera papayae* and in blocks without insecticide spraying beside those 5 insect pests was *Heliothis armigera.* These pests were found on all the varieties tested. The lowest populations of insect pests were recorded on lines G1 (WVCT-6) and variety G9 (Permata) and the highest incidence was on line G5 (WVCT-5) and variety G10 (Chung).

Liriomyza sativae and *N. tenuis* were considered to be the most important pests of tomatoes in this area. Infestation of *L. sativae* was heavier in blocks treated with insecticide than in untreated blocks. The only parasitoid that emerged from larvae of *L. sativae* was *Hemiptarsenus varicornis*. *N. tenuis* sucked the flower petiole and formed a yellow ring causing the flower buds to drop. *N. tenuis* was also observed feeding on small insects such as *Bessmia tabaci* and *Aphis* sp. but did not significantly reduce the pest populations. The fruit fly and its parasitoid were identified as *Bactocera papayae* and *Opius* sp. respectively. Nearly all varieties and lines used in this study showed an indication of viral infestation, particularly on shoots of plants with symptoms of *yellow mosaic virus* (YMV) in blocks both with and without insecticide sprayings. Only the line Anna (G8) was infested by a yellow dwarf virus.

Young tomato seedling infested with *Liriomyza sativae*

Tomato plant with symptoms of TYMV

Screening for virus disease resistance in tomatoes

Six varieties of tomatoes from AVRDC and four local varieties of tomatoes were studied to obtain information on agronomic characters of each line and variety. The longest life span of tomato plants was observed with G6 (WVCT-7 from AVRDC), G8 (Anna), G9 (Permata), and G10 (Chung) as compared to other genotypes. Genotype G7 (Amelia) was recorded as the tallest plant, with an average of 149.6 cm and the lowest was G10 (Chung) with 70.3 cm. The genotypes which were the quickest to flower were G1 (WVCT-6) and G9 (Permata) with 39 days after transplanting. Genotype G2 (WVCT-2) was the longest to flower, which was 45 days after transplanting. Genotype G10 (Chung) was the quickest variety for fruit to become mature (22 days) and G9 (Permata) was the longest (42 days) to become mature. Genotype G9 (Permata) gave the highest production of tomato (21.3 kg/bloc) and the lowest production was on G7 (Amelia) with only 4.5 kg/bloc. Only genotypes G7 (Amelia), G8 (Anna) and G10 (Chung) were not infected by tomato wilt. All lines from AVRDC were infected by tomato wilt.

Survey of parasitoids of *Liriomyza sativae* on tomatoes in Minahasa, N. Sulawesi

The objectives of this study were to identify and to estimate the percentage of parasitism by parasitoids on the leafminers infesting tomatoes in Minahasa. Since 2008, leafminers have become one of the most important pests of tomato, particularly in the tomato growing areas of Tompaso and Langowan. Lesser damage has been observed at Tomohon and Modoinding. For this reason, tomato farmers at Langowan and Tompaso have to spray their tomato crops very intensively.

The leafminer that infested tomato plants was identified as *Liriomyza sativae.* The parasitoids emerged from larvae of *L. sativae* collected from different centers of tomato growing in Minahasa were identified as *Hemiptarsenus varicornis, Gronotoma micromorpha, Neochrysocharis* sp. and *Opius* sp. The most dominant parasitoid was *H. varicornis*. The highest average parasitism was found at Paslaten, Tomohon where 42.33% of the sample of leafminers were parasitized by *H. varicornis*, 4.96% parasitized by *G. micromorpha* and 1.25% parasitized by *Neochrysocharis* sp. The lowest parasitism was found at Toure (Tompaso) where 10.89% of the sample was parasitized by only one parasitoid which was *H. varicornis*. These results indicated that pesticide spraying with pesticides on crops will kill natural enemies.

Role of women in farm enterprises of food and horticultural crops

The objective of this survey was to study the role of women in supporting farm enterprises of food and horticultural crops in North Sulawesi. Results showed that based on age of women there were no women laborers below the age of 20 years working in the field. Ages of women field workers fell in the following categories: 10.7% were between the ages of 21-30 years old, 32% were between 31-40 yrs, 30.7% were between 41-50 yrs and 26.7% were > 51years old. Workdays in the field were between 5 and 8 hours during the week.

In terms of education, 60% of the women had attended primary school, 25.3% intermediate school and 14.7% high School. In villages of Kakenturan and Rurukan, women with a high level of education (high school) normally acted as motivators. Most women laborers at Kakenturan have undertaken trainings such as Farmers Field School (SLPHT)

This study also showed that many women labors also knew the danger of using pesticides on crops. However, many farmers still use pesticides because they think it can increase the yield of their crops. All respondents claimed that they have a role in increasing the family income by 25-50 %.

Factors effecting cabbage farmer's decisions concerning adoption of an IPM program in Rurukan, Tomohon.

The objectives of this survey were to analyze factors that may affect a farmer's decision to adopt or not to adopt an IPM program and to estimate the tendency of farmers to adopt an IPM program as affected by different values.

Results showed that about 40% of the population at Rurukan is farmers, 2.3% civil servants, and 8.8% entrepreneurs, with the rest being students, retired or unemployed. About 45% of the farmers that apply IPM tactics have an average income > Rp 10.000.000 per year and only 10% of the farmers who do not apply IPM tactics have an income > Rp 10.000.000. Most of the low income farmers, earning <Rp 5.000.000, do not follow an IPM program.

Nearly all, or 95% of the farmers that follow IPM programs have undertaken IPM training and all the farmers who do not follow IPM principles have not undertaken any IPM training. The average production of cabbage for IPM farmers was 3612.2 kg/ha and non-IPM was only 3222.2 kg/ha. Labor costs for IPM farmers were Rp 4.040.000/ha and non-IPM were Rp 3.483.000/ha. The total revenue that IPM cabbage farmers received was Rp 20.000.000/ha and non-IPM farmers received Rp 17.261.000/ha. Total income that IPM farmers received was Rp 15.101.000 and non-IPM farmers only Rp 12.794.000.

The main factor that influenced farmers to adopt an IPM program on cabbage was the frequency of farmers who undertake IPM training and extension. IPM farmers tended to get higher income from their crop than the non-IPM farmers.

The effect of using plastic mulch and *T. koningii* on production of tomatoes

A block of tomato (variety Permata) was divided in half (10m x 20m each). One block had plastic mulch and the other did not. Each block consisted of 10 beds. After planting tomato seedlings, the beds were covered with plastic mulch as shown in Figure B below. The total number of plants in each block was 415, and each bed contained about 41 tomato plants. No additional fertilizers were added in the block with plastic mulch and there was no extra cleaning of the beds until harvest.

A. Without plastic mulch

B. With plastic mulch

Results:

Block without plastic mulch:

The total costs for fertilizers = Rp 460.000
Labor costs (cleaning etc) = Rp 360.000

Total = Rp 820.000 + costs for pesticides and labor for harvesting

Total production of tomato-83 boxes @ Rp 60.000* = Rp 4.980.000
Total output on block without plastic mulch Rp 4.980.000 – Rp 820.000 = Rp 4.160.000

Block with plastic mulch
Total cost for fertilizers = Rp 105.000
Labor = Rp 180.000
Plastic mulch = Rp 360.000

Total inputs = Rp 645.000 + costs for pesticides and labor for harvesting

Total production of tomato-117 boxes x Rp 60.000* = Rp 7.020.000
Total output on block with plastic mulch Rp 7.020.000- Rp Rp 645.000 = Rp 6.375.000
The price of tomato per box fluctuated quite highly between Rp 20.000/box to Rp 100.000.

Survey on parasitization of fruit flies in North Sulawesi

Samples of tomato fruit already infested by fruit fly from Toure/Tompaso and star fruit already infested by fruit fly from Manado were taken to the laboratory and the infested fruit was placed separately in the containers inside a muslin cloth cage. Pupae of fruit fly from tomato and from star fruit were again placed separately into a smaller container covered with muslin cloth. Each container contained 5-10 pupae. The plastic containers were placed in room temperature until the pupae emerged as adult fruit flies or parasitoids.

Of all the pupae collected from star fruit in Manado, 84 pupae or 66% emerged as adult fruit flies which identified as *Bactrocera carambolae* and 44 pupae or 34% emerged as parasitoids identified as *Opius* sp. All pupae collected from tomato at Toure (80 pupae) or 96.3% emerged as adult fruit fly and was identified as *Bactrocera papaya* and only 3 pupae or 3.6% emerged as parasitoids identified as *Opius* sp.

The low percentage of parasitism at Toure was due to the heavy use of pesticides on tomato.

Survey on papaya mealybug in North Sulawesi

A survey on the papaya mealybug *(Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) in North Sulawesi was initiated in April 2009. Pictures of papaya trees and fruits were sent to the IPM CRSP team at Clemson and to Dr. R. Muniappan at Virginia Tech for confirmation. This pest is wide spread in Manado. It can be found on the trunk, petiole, leaves, flower and fruits. Observation shows that the papaya trees die within 6-8 weeks after infestation, depending on the age of the tree. The papaya mealybug was also noted to infest cassava and ornamental plants such as *Euphorbia* spp.

Training on mass production and field application of a local strain of *Metarhizium anisopliae* to control insect pests at Modoinding

A farmer's group, which consisted of four men and 21 women at Modoinding, Sulawesi was given a special training on mass production and field application of a local strain of *Metarhizium anisopliae*. The participants were given lectures on pathogenic fungi followed by group discussion. During the discussion the participants learned how to identify insects infected by pathogenic fungi and determine which fungi has infected them. Different stages of development of pathogenic fungi on infected insects were also shown to the participants. The instructors demonstrated how to mass rear *M. anisopliae* using a simple and cheap method. They were also taken to the field to observe insect pests infected by pathogenic fungi. The participants were asked to collect healthy larvae of *Plutella xylostella* and *Crocidolomia pavanona* from the field. The two different larvae were separated and infected with the local strain of M. anisopliae.

IPM CRSP Seminar

A one day seminar on all IPM CRSP research and training activities (2008/2009) was held on July 3rd 2009. There were 12 papers on various topics of IPM that were presented at the seminar. This seminar was attended by professors M. Hammig, M. Shepard, G. Carners and staff and some graduate students of entomology and agronomy programs**,** post-graduate students in entomology and agronomy, teaching staff from Department of Plant Pests and Diseases, Faculty of Agriculture and representatives from the Bureau of Plant Protection, and Research and Development, North Sulawesi.

FIELD/Indonesia, North Sumatra, West Sumatra, Indonesia

IPM programs have been conducted in Lau Biang area (Barusjahe sub district, Karo district), Lembah Sibayak area (Berastagi sub district, Karo district), and Sibolangit area (Sibolangit sub district, Deli Serdang district), with collaboration between local community / farmer networks, ESP North Sumatera, FIELD Indonesia Foundation and Clemson University.

Farmer field study and field school on citrus in the Lau Biang area

The program in Lau Biang area was run by the farmer network "Jaringan Arih Ersada" (JAE), in the form of farmer field study/field school (FS) on Citrus, starting in September 2008. Seven units of FS were conducted in 6 villages (Serdang, Penampen, Siberteng – Kabung, Tanjung Barus, Sari Manis, and Tangkidik), led by farmer trainers of JAE. In these field schools, each farmer group conducted experimentation to compare 2 treatments in the following learning plots: Farmer practice and Ecological Treatment for Improvement. See Table 4.

Table 4: Farmer practice compared to ecological treatment

	Farmer Practice	**Ecological Treatment**
Number of Study plants	5 plants	5 plants
Plant age	Same	Same
Variety	Same	Same
Plot and Soil condition	Same	Same
Pruning	Just prune the air branch	• Major pruning 1-3-9 every 6 months • minor pruning every 1 month
Nutrition	Chemical fertilizer	• Solid compost 4-10 kg/tree/ 2 months, given in round under the canopy • Liquid compost 5 liter/tree/2-3 weeks • Added with natural growth regulator
Weed sanitation	Using herbicide or cut	Being cut and made as compost
Fall Fruit sanitation	Not picked up, let it stay in the field	Collected, and made as compost (solid and liquid)
Pest & Disease Management	Regular chemical pesticide spraying	• Using botanical pesticide according to the situation • Using natural enemies
Treatment if infected by stem canker	Use local practice (depend on location).	Using California mixture

The educational process of the FS citrus was started with 5 series of meetings to discuss the citrus ecosystem (components/players of citrus field ecosystem – their ecological function – functional relationship among players - and ideas for ecological management). From these discussions, the farmer group would then make determine their experimental design in the learning plots. Next would be bi-weekly meetings will be continued with 2 weekly meeting to do observation and agro-ecosystem analysis in the learning plots. In addition, they would also discuss special topics.

Early meetings

- Understanding about citrus field ecosystem: “players” in the field, their ecological functions, and functional relationship among players
- Management of sunlight and density of branches and leaves
- Nutrition and soil fertility
- Relationship between fallen fruit and certain pest cycles and nutrition distribution for the plant
- Making designs for learning plots

Bi-weekly meetings

Agroecosystem analysis and special topics:

- Composting, MOL and botanical pesticides
- Fallen fruit and its management
- Understanding more about natural enemies in the citrus field ecosystem
- Fruit fly and its management
- Understanding more on soil ecology
- Citrus diseases and their management
- Pruning of branches and fruit
- “Night life” in the citrus field ecosystem: players and ecological function
- Harvest and techniques for harvesting

Farmer field study on tomato in the Lembah Sibayak area

The program was run by the farmer network “Ersinalsal Lembah Sibayak”. During the period of October 2008 – July 2009, three sets of experimentation were conducted on tomato (variety: Martha):

1. Effect of compost dosage on the growth and yield of tomato (treatment A: 1 kg solid compost + 2 glasses of liquid compost/plant v/s treatment B: 0.5 kg + 1 glass of liquid compost/plant)
2. Effect of plant spacing on the growth and yield of tomato (treatment A: 40 cm v/s B: 20 cm)
3. Effect of number of branches left on the plant on the growth and yield of tomato (treatment A: 4 branches v/s B: 2 branches)

Each study used 2 treatments x 3 replicated plots with 100 plants for each plot.

Farmer field study on tomato

Farmer field study on cacao in Sibolangit

The study on cacao in Sibolangit was conducted by the farmer network "Formasi Pelita Kasih" (FPK). In this program, Formasi played a role in implementing the study, and in the result implementation and dissemination of the results, while FIELD – CLEMSON provided funds for the study implementation and technical support and ESP facilitated by the TOT, provided technical support for the study implementation, and will facilitate bi-monthly workshops for farmer researchers during the study period. The program started with TOT for Formasi's farmers on 30 March – 2 April 2009. The Formasi group then designed and conducted 3 field studies on cacao in 3 villages in Sibolangit: Batu Layang, Rumah Pil-pil and Rumah Sumbul, involving around 25 farmers – both men and women from 9 villages of Formasi's network. The 3 studies, described below, are ongoing:

1. The effect of plastic sleeves and sanitation for the management of cacao pod borer.
2. The effect of sanitation and organic fertilizer for the management of fry pod fiseases.
3. The effect of pruning and organic fertilizer for cacao plant growth.

Farmers conducting a field study

The effect of using plastic sleeves and sanitation for the management of the cocoa pod borer

Cocoa Pod Borer (CPB) is one of the most damaging pests in Sibolangit, making it an important issue in cacao management in the area. Therefore, Formasi select this topic for study.

Objective

- For FormasiI farmers to complete a study on, understand more about, and to find management solutions for CPB.

Output

- Around 10 Formasi farmers will be able to understand and complete a farmer field study on CBP.
- Data and information related to CPB will be generated
- Ideas on Ecological CPB management will be formulated

Study Design

This study will compare 4 treatments to see their impact on CPB (Table 5 and 6):

A: Using plastic sleeves to cover the pod
B: Sanitation (material from sanitation procedures will be composted and used as fertilizer for the plants)
C: Using a combination of plastic sleeves + sanitation
D: Control (using neither sleeves – nor sanitation)

Notes:

1. There will be 12 small "plots ."
2. In each small plot, there will be 9 cacao plants, all receiving the same treatment according to the study design.
3. Observations will be conducted on the sample plant located at the center of the small plot (red color), while surrounding plants will act as barriers to reduce bias.
4. All 12 small plots will receive the same maintenance treatments, such as pruning and fertilizing. The only difference will be in the use of the plastic sleeve and sanitation, according to the treatment design.

Table 5: Observation plan related to effect of the use of plastic sleeve

Object to Observe	**Measurement**	**Method of Observation**	**Time**
Infestation of CPB	number of infested pod	Count number of pod per plant both infested and uninfested	Once per 2 weeks, from beginning of study to harvest
Pod growth	cm	Measure length and circumference of pod	Once a week, from beginning of study to harvest
Pod maturity	Days	Count days needed by pod to grow from size around 8 cm to harvest	from beginning of study to harvest
Cost	Rupiah	Count the cost	from beginning of study to harvest
CPB caterpillar	Number of caterpillar per pod	Count the number of caterpillar in the sample pods	from beginning of study to harvest
Benefit	Rupiah	Result of yield selling – cost	from beginning of study to yield selling

Table 6: Observation plan related to effect of sanitation

Object to Observe	Measurement	Method of Observation	Time
Infestation of CPB	Number of infested pod	Count number of pod per plant both infested and uninfested	Once every 2 weeks, from beginning of study to harvest
Soil fertility	Number of earthworm	Count the number of earthworm in the soil around root system (40x40x25cm)	Once a month from beginning of study to harvest
Growth of: - Stem - Leaves - Root	cm cm cm	• Measure plant height from soil surface to main branch; and circumference of stem at 30 cm above soil surface. • Measure length and width of leaves samples (3 leaves/plant from several branch) • Dig soil around the root system and measure root length from stem base to root tip.	Once a week from beginning of study to harvest Once a month from beginning of study to harvest

Impact of sanitation and organic fertilizing on cacao dry pod disease

One of the main cacao problems in Sibolangit is dry pod disease, where infested pods rot and dry. The rotting process starts when pods are still small. This causes production to be reduced since many of the pods cannot reach their maximum size. This disease is called “virgin rot” in the local communities, meaning that the rotting process begins in a very early stage of the pod. Dry pod disease is such a significant problem that many Formasi farmers chose it as one of the topics for study.

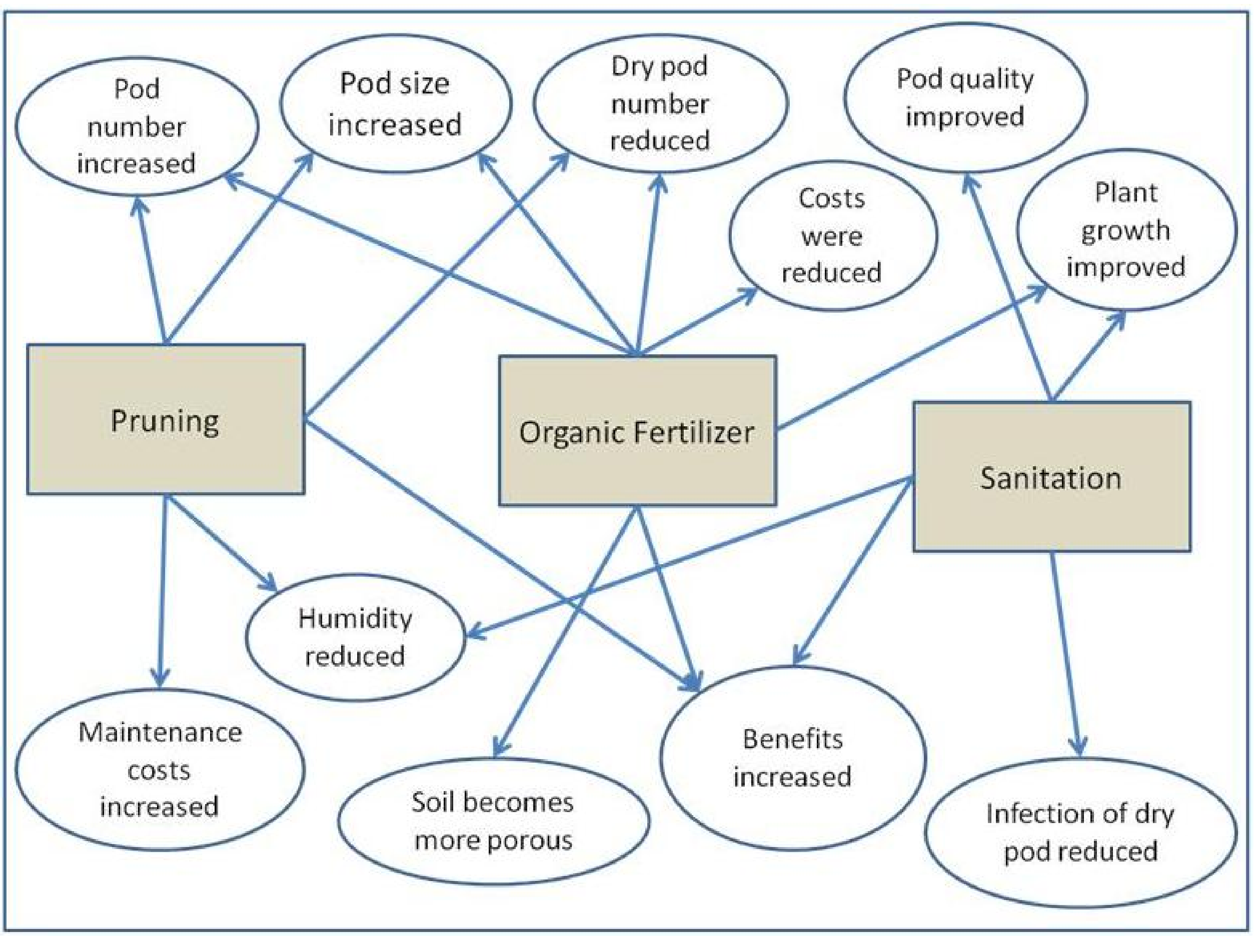
Output

- Around 10 Formasi farmers will be able to conduct a study on dry pod disease.
- Information and data as the result of the research
- Ideas for the ecological management of dry pod disease

Study design description:

A: Sanitation (dry pod collected) but thrown away + pruning
B: Sanitation (dry pod collected), and to be composted and given to plant as additional organic fertilizer + pruning
C: Control (no sanitation, no additional compost, no pruning)

All treatments including the control will receive basic compost



Impact of pruning and organic fertilizing to the growth of the cacao plant

The community's cacao plantations in Sibolangit are still not well managed. After planting, plantation owners rarely care for their plantations, returning only for harvest. Therefore, production is poor and many plants are infested by pests and diseases. These poor management practices impact the weight of seeds produced and also the selling price, as yields are often below market standard. Responding to this situation, Formasi farmers will try to improve plant growth. To do so, a study will be conducted to determine the impact of pruning and organic fertilizing on the growth of the plants.

Through this research, Formasi farmers will learn about the impact of pruning and organic fertilizing on the growth of the plant, and then generate ideas for improving the cacao plantation management ecologically.

Outputs:

- 10 Formasi farmers will conduct the study
- Data and information as a result of the study
- Ideas can be generated for improvement of cacao plantation management in an ecological manner.

Study Design
The study will be conducted with 3 treatments:
A: Pruning + organic fertilizing
B: Pruning only
C: Control (no pruning, no organic fertilizing)

Notes:

1. There will be 9 small "plots"
2. In each small plot there will be 9 cacao plants that will be treated the same according to the study design.
3. Observations will be conducted on the sample plant, located at the center of the small plot (red color), while surrounding plants will act as barriers to reduce bias.
4. 6 plots will be pruned, while 3 others will not be pruned as control

West Sumatra

This farmer study in West Sumatra was started in April, 2009, and managed by Sajati Farmer Group of Jorng Sungai Sariak Nangari Koto Tinggi, a sub district of Baso, Agam district. The topics of the study were: "Comparison study of the sweet potato weevil (*Cylas formicarius*) attack on organic sweet potatoes with non-organic sweet potatoes" and "Life cycle study of the sweet potato weevil (*Cylas formicarius*)". This is an ongoing program.

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Eggplant IPM

New promising technologies as well as technologies developed from previous IPM CRSP field researches are continuing to be verified in on-farm station studies in southern Luzon provinces. For the cropping season 2008-2009, technology development, verification and dissemination studies were conducted in Laguna province, in the village, Imok.

For technology development, a study was conducted in a farmers' field in Imok to verify efficacy of promising IPM CRSP technologies in reducing insects, diseases, and weeds infesting eggplant compared to existing farmers' practices in the area. Results showed that using grafted seedlings and applying pre-plant treatments of VAM (vesicular arbuscular mycorhiza) to seedbeds resulted in reduced eggplant damage caused by bacterial wilt and phomopsis diseases by more than 90% over those of non-grafted seedlings. Use of predatory earwigs, *Trichogramma*, and removal of infected plant parts reduced damage due to the eggplant fruit and shoot borer by 80 to 90% and due to leafhopper infestation by 44 to 60%. The stale-seedbed technique of two sequential harrowings at 14-day intervals and mulching reduced weed infestation by about 20%. Except for use of grafted seedlings, the IPM practices reduced weed control costs by 62%, insect control costs by 29% and disease control costs by 39%, reducing total production costs by 21%. While use of grafted seedlings cost five-fold more than non-grafted seedlings, it increased yields and crop values by two-folds more than those of non-grafted seedlings. Total crop values and profits are yet to be determined as harvest is still ongoing.

To disseminate IPM technologies, several activities were conducted: 1) survey of 33 farmers in four villages of Calauan, Laguna, on their vegetable production and pest management practices which was conducted from October to November 2008; 2) one-day training seminars on IPM CRSP pest management technologies held on December 12, 2008 and on July 31, 2009 attended by a total of 61 farmers (38 men and 23 women); and 3) technical assistance to the "Gawad Kalinga" project, a combined housing and vegetable production project of the Department of Agriculture and the Couples for Christ, by giving lecture-demonstrations on IPM technologies and providing the project participants with biological control agents to manage vegetable pests.

Dissemination of IPM technologies

In the field survey, the major insect pests of vegetables in Calauan were semi-loopers, cutworms, and fruit and shoot borers; the major diseases were damping off, soft rot and phomopsis while the major weed problems were purple nutsedge, spiny amaranth and dayflower. Almost all of the farmer-respondents said that they started applying pesticides (insecticides and fungicides) at 1 week after planting, with a total of 10 or more applications during the cropping season, at all stages of crop growth. These include insecticides (malathion, brodan, selecron, lannate, cymbush, furadan, karate), fungicides (dithane) and herbicides (glyphosate and fluazifop). The farmers spend from P1000 ($22) to more than P5000 ($106) for pesticides in one cropping season. Hand weeding is done from four to ten times (every two to three weeks), costing about P5000 ($106) to P9000 ($200) per hectare for one cropping season. Herbicides are applied once or twice for the whole season, costing P1000/ha ($22/ha). Most of the respondents (82%) have not attended Integrated Pest Management (IPM) training; and only 18% have attended an IPM course and learned about *Trichogramma* and other natural enemies.

A training-seminar on integrated pest management (IPM) in eggplant was conducted on December 12, 2008 for 39 vegetable farmers (16 men and 23 women) from eight villages in Calauan, Laguna in cooperation with the Department of Agriculture Local Government Unit of Calauan. The seminar-workshop featured a lecture-demonstration of some IPM techniques and an open forum with the IPM CRSP researchers serving as resource persons. Among the topics discussed was the eggplant grafting technique to increase resistance of local commercial cultivars to bacterial wilt, a very serious disease of eggplant in Southeast Asia. The grafting technique procedure was demonstrated to farmers. After the demonstration, the farmer-participants were given a "hands-on" experience by doing the grafting themselves. The training-seminar on July 31, 2009 was also held in the Department of Agriculture Local Government Office of Calauan and was attended by 22 vegetable farmers (15 men and 7 women) also from Calauan, Laguna. IPM CRSP researchers gave a lecture-demonstration on IPM technologies to manage pests in vegetables including the eggplant grafting technique and use of earwigs to manage insect pests infesting vegetables.

IPM CRSP is also providing technical assistance to a housing and vegetable production project of the Department of Agriculture and the Couples for Christ (CFC). Known as "Gawad Kalinga/ Goodbye Gutom" (translation: to give care/goodbye hunger), the project was launched on March 8, 2009 on Gawad Kalinga areas all over Luzon. IPM CRSP researchers attended the project launch at the GK site in Sta. Cruz, Laguna. The objective of the project is to provide housing and a sustainable source of food for the project participants consisting of poor families in a particular site. Each family maintains a 10 m^2 vegetable plot planted in okra, eggplant, tomato, bittergourd, pac choi, cabbage, crucifers and other vegetables. As part of the IPM CRSP dissemination activities, a lecture-demonstration on mass rearing of earwigs and grafting of tomato (scion) and bacterial wilt resistant variety of eggplant Eg203 (root stock) was conducted on May 21, 2009 at the GK site in Sta Cruz, Laguna. About 30 GK project participants coming from different areas in the Philippines attended the said training. IPM CRSP also provided initial materials for mass-rearing of natural enemies (earwigs and *Trichogramma*) as biological control agents against pests infesting the vegetable plots.

Objectives:
1) To evaluate effectiveness of grafting, host plant resistance, and soil additives (VAM) in reducing bacterial wilt infection and other soil-borne pathogens infesting eggplant; 2) To evaluate efficacy of pre-plant (stale-seedbed) and post-plant (hand weeding) control methods for weed control in eggplant; 3) To evaluate efficacy of cultural (mulching), mechanical method (removal of damaged parts) and biological (earwig, *Trichogramma*) control methods against insect pests infesting eggplant; 4) To provide technical assistance and biological control materials to the vegetable production project of the Department of Agriculture and the Couples for Christ.

IPM constraint

In eggplant production, the major problems are bacterial wilt caused by *Ralstonia solanacearum* and phomopsis blight caused by *Phomopsis vexans*, both of which limit production. In 1998, bacterial wilt caused 15, 40, and 30% wilt incidence on eggplant in Batangas, Nueva Ecija, and Pangasinan, respectively. Major insect pests of eggplant are the fruit and shoot borer (*Leucinodes orbonalis*) and leafhoppers. In most cases, farmers stopped planting eggplant due to bacterial wilt or fruit and shoot borer infestation. Weeds are also major constraints, particularly purple nutsedge (*Cyperus rotundus*) and broadleaf weeds like spiny amaranth (*Amaranthus spinosus*), which are the major problem weeds in vegetables, causing more than 50% yield loss when allowed to grow uncontrolled in vegetable crops.

Survey of vegetable farmers in Calauan, Laguna showed that chemical control is the major pest management method of most farmers, costing them an average of $100/ha per cropping season, with a maximum of 10 pesticide applications or 10 hand weeding operations during the cropping season. These methods are expensive and tedious and also pose potential hazards to human health and the environment.

Agroecological strategies such as the use of natural enemies and crop production practices such as mulching or harrowing can help reduce pest populations at minimum input costs. These methods are also less hazardous to human health and the environment. Currently, there is no integrated and holistic approach for managing pests in eggplant and other vegetables in the Southern Luzon area. There is a need for development of environment-friendly as well as input-reducing technologies that will reduce pest populations in eggplant and provide not only high yields but also increased profits for farmers.

On-farm evaluation of promising component technologies to manage pests infesting eggplant in Calauan, Laguna

The study was conducted in southern Tagalog region about 60 kms south of Manila, in Barangay Imok, Calauan, Laguna, from June to September 2008. The seedbed was prepared by adding 10 kg/ha of VAM (vesicular arbuscular mycorrhiza) at about 0.5 cm thick to autoclaved garden soil. (The farmers' seedbed was not treated with VAM). Forty-five day old seedlings of non-grafted and grafted eggplant cultivar 'Casino' (for IPM plots) were transplanted into 1.2 by 0.9 m plots (15,000 seedlings/ha) on July 3, 2009. Ammonium sulfate (21-0-0 NPK) fertilizer was applied (175kg/ha/ application) at 14 and 28 days after transplanting (DAT). Foliar fertilizer (Nutrigrow, 19-19-19 NPK) was sprayed at 30 DAT. Plants were irrigated as needed with a deep-well pump and soil moisture maintained at field capacity. Eggplant fruits were harvested starting from 56 to 119 DAT.

The IPM treatments were as follows: a) weed management: stale-seedbed plus 2.5 cm mulch applied at 25 DAT, followed by one hilling up at 15 DAT; b) disease management: use of grafted seedlings (Casino cultivar grafted with EG-203, a bacterial wilt-resistant cultivar developed by AVRDC) and non-grafted Casino; then treated with Mycovam (vesicular arbuscular mycorrhiza); c) insect pest management: earwigs (*Euborelia annulata*) released at 25 and 32 DAT (20,000 earwigs/ha) followed by six releases of *Trichogramma* cards (50 Tricho cards per release) starting at 30, 34, 38, 42, 49, and 56 DAT and removal of damaged shoots and fruits caused by shoot borer. For the stale-seedbed technique, the area was plowed once and harrowed once 4 weeks before planting followed by another harrowing 3 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.

Earwigs, collected from borer-infested corn fields, were reared in the laboratory in acrylic pans (14.5 cm wide x 8.5 cm depth) containing 2-3 cm vermi-compost soil. A colony can be started with 5 acrylic pans, each containing 6 female and 3 male adult earwigs. The earwigs are fed with 1 tablespoon fry mash every 10 days. The females are allowed to lay 4 to 6 batches of eggs (40 eggs/batch) and eggs are allowed to hatch within 7 to 9 days. From the stock colony, 150 female and 50 male adult earwigs are placed inside a mass rearing box (37.5 cm x 73 cm x 28 cm) containing vermi-compost soil. The adults are fed with 400 g of fry mash initially, then with 200 g fry mash per box every 10 days. Additional cultures can be prepared by collecting the third instar nymph, placing them in another acrylic pan with vermi-compost soil and feeding them until adulthood. At least 10 rearing boxes should be maintained for a 1-ha vegetable farm and should be set up 1.5 months ahead of planting date. The earwig adults are released twice, at 7 and 14 DAT, with two earwigs/m^{-2} or a total of 20,000 earwigs ha^{-1}. Continuous release of earwigs every cropping season is necessary to establish adequate earwig population in the vegetable field. Mulching with rice straw at 7 DAT provides refugia for earwigs while preplanting cultural practices such as plowing and harrowing reduces earwig populations.

The treatments were replicated three times and laid out in a randomized complete block design. Insect, weed and disease incidence were recorded every 14 days. Weed density and fresh weights were recorded at 56 DAT. Incidence of bacterial wilt and phomopsis blight was monitored in each plot at 14-day intervals and expressed as percent of plant or fruits damaged. The incidence of fruit and shoot borer and leafhopper was recorded at 14-day intervals and expressed as percent of plants or fruits damaged. Weights of marketable and non-marketable fruits were recorded and yield expressed in t/ha. Cost of all crop protection and crop production inputs were recorded to estimate net profits obtained from IPM and farmers' practices.

Data for farmers' practice plots were collected from a neighboring eggplant vegetable farm. The farmers' practice plots were not treated with VAM during seedbed preparation. Non-grafted, 21-day old seedlings of cv. Casino were transplanted on June 15, 2009. The farmer's practices were as follows: a) weed management: clearing of area with scythe or bolo, followed by 1.44 kg ai/ha glyphosate (*N-phosphonomethylglycine*) applied to existing weed vegetation 7 days before planting followed by another clearing; the area was plowed twice and harrowed once immediately before transplanting, followed by 6 hand weedings starting at 14, 28, 42, 56, 70 and 84 days after transplanting; b) disease management: non-grafted seedlings of eggplant cultivar Casino were used and applied with Mancozeb (mancozeb 0.08 kg ai/ha) at 14-day intervals at 45, 59, and 73 DAT, c) insect management: Furadan (carbofuran, 0.4 kg ai/ha) sprayed during replanting, followed by application of Lorsban (chlorpyrifos, 0.4 kg ai/ha) at 2 week intervals starting at 45, 59, 73 DAT. As in the IPM plots, cost of all crop protection and crop production inputs and crop yields were recorded to estimate net profits.

Insect, disease and weed infestations were lower in the plots treated with IPM strategies in both grafted and non-grafted seedlings compared to plots treated with farmers' practices. Weed infestations were lower by 23%, fruit and shoot borer damage by 88 to 98%, leafhopper damage by 44 to 67%, and phomopsis infestation by 96 to 100%, than those of plots treated with farmers' practices.

Production costs were reduced by a total of 21% compared to production costs in farmers' practice plots, with a 62% reduction in weed control costs and a 29% reduction in insect control costs (Table 7). Disease control costs were reduced by 36% except for use of grafted seedlings which costs about five-fold higher than non-grafted seedlings. This increased total production costs in grafted seedlings by 16% more than in farmers practice plots. When non-grafted seedlings are used, total production costs in IPM practices is 21% lower than those in farmers' practices plots.

Eggplant yield was 1.5-fold higher and crop value about 2-fold higher in IPM plots with grafted seedlings than those of farmers' practice plots and those of IPM plots with non-grafted seedlings (Table 8). Eggplant yield in IPM plots with non-grafted seedlings were 28% lower and crop value lower by 16% compared to farmers' practice plots. At the time of this report, eggplant harvest is ongoing, thus total crop value and net profits are yet to be determined.

Data show that IPM practices reduce insect, disease and weed infestations at lower costs than farmers' practices except for use of grafted seedlings which is more expensive than use of non-grafted seedlings. Previous economic analysis done on use of grafted seedlings showed that this IPM practice is more beneficial during periods of high bacterial wilt infestation. If there are ways by which costs of the grafting process can be minimized, then this practice could also provide high economic benefits to farmers in areas with high bacterial wilt infestation.

Table 7: Degree of insect, disease and weed infestation in eggplant treated with IPM and farmer practices in a farmer's field, Calauan, Laguna, June-September 2009

Treatment	Weed fresh weight (g/m^2)	FSB (% damaged fruits)	FSB (% damaged shoots)	Leafhopper (% damaged plants)	Phomopsis (% fruits damaged)
IPM and non-grafted eggplant	298 (23)*	2% (88)	5% (89)	15% (44)	1% (96)
IPM and grafted eggplant	298 (23)	2% (88)	1% (98)	9% (67)	0% (100)
Farmer practice and non-grafted eggplant	387	17%	47%	27%	24%

*Figures in parentheses indicate percent reduction over farmer practices.

Table 8: Eggplant yield, crop value, pest control and total production costs and net profits in eggplant treated with IPM, and farmer practices in Calauan, Laguna, June - September, 2009.

Treatment	Yield (t/ha)	Crop Value ($/ha)	Weed Control Cost ($/ha)	Insect Control Cost ($/ha)	Disease Control Cost ($/ha)	Total Production Cost ($/ha)
IPM and non-grafted eggplant	0.45	244	107 (62)*	65 (29)*	52 (36)*	379 (21)*
IPM and grafted eggplant	0.97	528	107 (62)*	65 (29)*	408	558
FP and non-grafted eggplant	0.63	294	285	92	81	480

*Figures in parentheses indicate percent reduction over those of farmer practices.

Dissemination of IPM CRSP technologies:

Monitoring of pest incidence and crop yields in Gawad Kalinga vegetable plots treated with IPM CRSP technologies
Technologies developed from IPM CRSP research consisting of: 1) biological control of fruit and shoot borer using *Trichogramma* and earwigs; 2) removal of damaged plant parts to control fruit and shoot borer and phomopsis blight; and 3) use of rice hull mulch to serve as refugia for earwigs and reduce weed populations were applied in the mixed vegetable plots at the Gawad Kalinga project in Sta. Cruz Laguna. Low fruit and shoot borer and leafhopper populations, low weed densities and low incidence of phomopsis resulted in high eggplant marketable yields. These crop protection inputs not only reduced pest incidence resulting in increased yields but also have low costs, thus increasing net incomes for the growers.

The study was conducted at the GK site in Jasaan, Sta Cruz, Laguna. The seeds were provided by the Department of Agriculture and seedlings were grown at the Central Luzon State University then transferred to the sites. A total of 34 families participated in planting the vegetables. Each family prepared two 10 m^2 plots in raised beds. Before transplanting, organic fertilizer at 15-20 kg/10 m^2 and rice hull mulch was applied (3 sacks of rice hull/10m^2 plot) to serve as refugia for earwigs and to suppress weed growth. Twenty one day old seedlings of eggplant cultivar Casino were transplanted into 10 m^2 plots (50,000 seedlings/ha) on March 8, 2009. Four other vegetables (okra, bitter gourd, tomato, string beans and kangkong, also known as water spinich) were also grown in the same plots where the eggplant was grown. To manage insects, earwigs (*Euborellia annulata*) were released at 7 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, and 56 DAT. Removal of plant parts damaged by insect pests and diseases and hand weeding were done regularly. Monitoring of insect and disease incidence was done at 14-day intervals. Weed density and fresh weights were recorded at 28 DAT. Bacterial wilt and phomopsis blight were monitored in each plot at 7-day intervals and expressed as % damaged plants. The incidence of fruit and shoot borer was expressed as percent damaged fruits. The incidence of leafhopper was expressed as percent damaged plants. Plants were irrigated as needed with a deep well pump and soil moisture maintained at field capacity. Eggplants were harvested 45 days and counting after transplanting. Cost of pest control inputs was estimated and crop yields and values were recorded to calculate net profits. Because hand weeding was done by the growers themselves, the time spent for this activity was recorded and the corresponding daily wage rate for labor was used to calculate labor costs for hand weeding.

There was low infestation, only 10 to 18% damaged shoots or fruits plant parts caused by fruit and shoot borer, bacterial wilt and phomopsis blight (Table 9). There was zero weed infestation because the small plot size allowed regular hand weeding operations to be carried out. The only pest which was observed to have high infestation was the leafhopper which showed 62% damaged to plants. The input cost for disease control was lowest at \$22/ha, followed by input cost for insect control at \$73/ha, and highest inputs were spent on weed control particularly on costs of labor for hand weeding. With eggplant yields of 3.91 t/ha (marketable and non-marketable yield) valued at \$1772/ha and total production costs estimated at \$514/ha, the net income was estimated at \$1258/ha (Table 10).

Table 9: Degree of insect, disease and weed infestation in eggplant treated with IPM technologies

Treatment	Weed FW (g/m^2)	FSB % damaged shoots	FSB % fruit damaged	Leaf Hopper % plants damaged	Bacterial wilt % plants damaged	Phomopsis % fruits damaged
Integrated Pest Management	0%	17%	18%	62%	18%	10%

Table 10: Eggplant yield, crop value, pest control and total production costs and net profit in eggplant treated with IPM

Treatment	Yield (t/ha) marketable	Yield (t/ha) non-marketable	Crop Value ($/ha)	Weed Control Cost ($/ha)	Insect Control Cost ($/ha)	Disease Control Cost ($/ha)	Production Cost ($/ha)	Net Profit ($/ha)
IPM	3.19	0.72	1,772	89	73	22	514	1258

The data confirm the efficacy of the IPM technologies in reducing pest populations in eggplant at minimum input costs, which will increase yields and net incomes of vegetable growers. The low incidence of bacterial wilt in the area did not require use of bacterial-wilt resistant grafted seedlings, which minimized the cost of the control inputs, thus resulting in increased net profits.

Results from the on-farm studies being conducted this year and for the past four years show the efficacy of IPM CRSP technologies in reducing pest populations. Since these strategies are based on agroecological principles using natural enemies and cultural production practices designed to increase crop competitiveness against pests, they are also less expensive by 30 to 60% with about two-fold increase in crop yields and can increase net profits by about 20%. These agroecological approaches also pose less potential hazards to human health and the environment.

IPM CRSP has provided technical assistance to the Department of Agriculture and the Gawad Kalinga ("to give care") vegetable production project. The Gawad Kalinga project is a holistic community program that aims to eradicate poverty and hunger in the Philippines by providing housing and vegetable production activities to participating families, mostly from the urban poor. By introducing IPM technologies such as mass-rearing of earwigs and eggplant grafting techniques, the participants are now aware of the IPM methods. Low pest incidence and high yields from their eggplant plots due to the IPM methods can result in high profits for the growers. Since this is a nationwide project of the Department of Agriculture, IPM CRSP involvement, starting with the central and southern Luzon provinces, has the potential to provide a big impact on vegetable production in the country.

Networking activities

Dr. Merle Shepard traveled to the Philippines in January 2009 to observe IPM CRSP experimental plots and the Gawad Kalinga vegetable plot sites in southern Luzon, Philippines and to discuss experimental results with UPLB IPM CRSP co-PIs.

A farmer-participant is learning how to prepare bacterial-wilt resistant grafted seedlings during the IPM CRSP training seminar held at the Department of Agriculture office in Calauan, Laguna, in December, 2008. Supervising the trainees is IPM CRSP researcher Joana L. Opena (left), one of the resource persons during the training seminar.

PhilRice

Participants in one of the farmer trainings conducted during a lecture session. Inirangan Bayambang, Pangasinan

Participants inoculating corn substrate with *Trichoderma* sp. (IPM CRSP isolate)

Participants weighing their *Trichoderma* sp. product

Technical briefings In February 2009, an information caravan was conducted in 13 barangays of Bayambang, Pangasinan. This is actually a follow-up of the information campaign on the OPLAN Sagip Sibuyas conducted earlier in Bayambang, Pangasinan. During the caravan, farmers in each site were gathered and briefings were made on IPM in onion. The available IPM technologies were presented to create awareness on the availability and benefits that could be derived from using the technologies. There was open forum in each of the sites. Farmers were so interested in these technologies that a decision was made at some barangays to have follow-up activities. The first activity requested was farmer training. At three of the sites a decision was made to have training in April. The other sites will have the training, but have not decided on date or location.

Farmers' Participatory Technology Demonstration (PTD) Six PTDs were established in sites where the FFS were conducted. These served as the training fields for the participants for the whole duration of the cropping season. So far, there have not been many problems in the conduct of the PTDs. Yield and net incomes were higher in the IPM plots than in the farmers' practice.

No VAM applied

With VAM

Farmers' participatory technology demonstration conducted in Bayambang, Pangasinan. Note the stand of onion without VAM – few plants survived, compared with the plants that have a much better crop yield when VAM is applied (left).

- ***Field Days***

One farmer field day was conducted in San Agustin, San Jose City, Nueva Ecija. It was attended by more than 100 farmers, coinciding with the FFS graduation in the barangay.

Field day in San Agustin, San Jose, Nueva Ecija, 2009

Media releases Uploading of media releases on the different IPM technologies in the campaign blog site is being continued.

Information caravan An information caravan was conducted in 14 sites covering 19 other onion-producing barangays. The aim of the caravan was to inform other farmers about the campaign, promote the Farmers' Text Center and to encourage farmers to organize their own farmer group to hold an FFS on IPM. More than 300 sets of flyers on IPM approaches were given out to farmers and more than 100 sets of technology posters were distributed.

Farmer Field School graduation More than 40 farmers in each of the focus barangays participated in the season-long farmers' field school on IPM in onion. In March, these farmers graduated and were awarded certificates of completion and participation. During post-campaign interviews, many of these farmer-participants claimed that they were able to increase the yield and quality of their harvest, and at the same time reduce the amount of fertilizer applied in their field because of their use of VAM and Trichoderma. Others said that they were able to effectively manage common insect pests by using blue and yellow board sticky traps, thereby reducing the use of pesticides.

Exhibit The campaign team participated in the Bayambang town fiesta by putting up an exhibit featuring the different IPM technologies promoted in the campaign during the town's Farmers' Day. Farmers who visited the exhibit were given free posters and flyers to take home. The exhibit also showcased the best onion products of some of the farmers.

Campaign evaluation Two sets of focus group discussions (FGDs) were conducted in each of the focus barangays to gather farmers' feedback on the campaign (descriptive, qualitative data). The participating farmers also answered the post-test questionnaire to determine if they were able to enhance their knowledge on, attitude towards, and practice of the key IPM technologies promoted (quantitative data). For the farmers outside the focus barangays, a survey among 100 farmers was conducted to determine the extent of reach of the campaign.

Quantitative data analysis is still on-going. Results of the FGDs however show that while pre-campaign surveys revealed that the use of VAM and Trichoderma were the technologies farmers had the least knowledge of, post campaign knowledge, attitude and practice (KAP) interviews revealed that these two technologies are the most frequently-recalled among farmers inside and outside the focus barangays. VAM and Trichoderma were also considered the most important and helpful technologies taught during the campaign.

FGD results further revealed that farmers found the participatory approach of the campaign activities very helpful in overcoming the "to-see-is-to-believe" attitude among farmers. Since the activities included farmers doing actual field work and managing their technology demonstration farms, they were able to see firsthand the advantages of the technologies over their usual management practices.

Creation of plan for campaign expansion Because of the success of the campaign in the two focus barangays, onion farmers from the other barangays in Bayambang have requested that the same activities be held in their area. Thus, there is a plan to expand the campaign to other barangays and to introduce new information dissemination strategies using information communication technology (ICT) for the next onion planting season.

Campaign materials produced according to target (quantity and quality) Eight different kinds of posters were printed in 1,000 copies each and eight different kinds of flyers were printed in 3,000 copies each. To date, these are already distributed and we are reprinting them. T-shirts bearing the campaign logo (150 pcs) were also printed. Fifty copies of the technology videos (VAM and *Trichoderma)* were also produced for the agriculture office and technicians. A blog was created where media releases about IPM technologies in onion as well as press releases on the campaign activities were posted. Tarpaulin banners (2) were also printed for the two focus barangays, and a campaign jingle was produced.

Campaign strategies carried out To spur awareness of the campaign and to formally launch it as a collaborative project with the Bayambang LGU, a campaign launching was held on September 24, 2008. Farmers from the different onion-producing barangays in Bayambang were invited. The launching included a parade around the town proper, a mini-exhibit, farmers' forum, singing of the campaign jingle, MOA signing, and raffles.

The principal method of information dissemination is the Farmers' Field School (FFS) where farmer-participants in the focus sites discuss in detail the different IPM practices in onion. In the FFS, farmers engage in actual field work where they learn the technologies first hand. These technologies are applied to the technology demonstration site which is managed by a farmer-cooperator and is located strategically to be seen by other farmers (along with the campaign banner). Aside from the demo site however, farmers are also encouraged to allot a small portion of their individual farms for an individual demo site.

The FFS discussions are supplemented with reading materials which farmers are allowed to take home. This is in the form of posters and flyers. The poster messages are framed in such a way that they tease farmers to read them. These posters are placed in strategic areas in the community where they can be seen even by passers-by. The posters have smaller versions in the form of a flyer which contains a more detailed description of the technologies. The farmer-participants are also given additional copies of the flyers which they give out to other farmers who are not in the FFS. The posters and flyers are all produced in Filipino to enhance understandability and in a variety of colors for attractiveness.

T-shirts were distributed to the FFS farmer-participants and it served as their 'school uniform.' But since the shirts are as mobile as the persons wearing them, the shirt will hopefully reach other areas and help spur awareness about the campaign.

The campaign jingle produced was to the tune of a popular novelty song but the lyrics were altered bearing the message that farmers should start practicing IPM. Since the tune is popular, the jingle will more likely be remembered.

An info caravan wherein the campaign team visited the other onion-producing barangays was also held during the onset of the harvest season. The aim of the caravan was to inform other farmers about the campaign, promote the Farmers' Text Center and to encourage farmers to organize their own farmer group to hold an FFS on IPM.

Knowledge, attitude, and practice of IPM enhanced The campaign is still in progress so no post-test evaluation has yet been conducted. However, based on monitoring activities, major observations have been made about the conduct of the campaign. One is that it pays to start with what farmers know and do. This emphasizes the importance of a baseline data that gave the campaign team a good idea of which pest and disease management practices the farmers are doing wrong or right. From these data, the team was able to focus on the worst aspects of the farmers' practices. By correcting farmers' perceptions about the 'worst practices', the campaign is expected to achieve greater impact.

Another is that it is important that the LGU personnel, ATs and farmers are directly involved in the planning and implementation of the campaign. Involving them will result in them feeling a sense of ownership of the project. With this, they are more likely to participate and give their best to help make the campaign a success.

Although there is no formal data yet, it is observed that a combination of different communication activities and strategies is more effective than focusing on one strategy alone, the FFS. Different strategies were targeted to different sets of audiences and were aimed to achieve different goals. When the individual effects however are combined, a greater impact is achieved.

Management of leafminer, *Liriomyza* spp. on vegetables grown after rice with naturally occurring natural enemies: collection, identification and assessment of predators of Leafminer—*Liriomyza* spp.

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

Natural enemies of leafminers are considered key factors in their management. Results of our earlier studies indicated that insecticide application resulted in more problems due to the destruction of naturally occurring natural enemies. Development of management strategies against leafminer should be focused on the use of naturally occurring biological control agents. In a survey we conducted earlier, larval parasitism was high in some locations and in some vegetable crops in spite of the fact that most of the fields sampled were sprayed with insecticides.

Studies conducted in Thailand indicated that predatory flies had a big impact in reducing populations of leaf miner adults. Several species of *Coenosia* flies were identified feeding on aphids, leafhoppers whiteflies and leafminers. This predator was reported to significantly reduce damage due to leafminers in greenhouse trials.

It is therefore important to search for alternative management strategies to effectively manage leafminers in vegetables and other crops. This study aimed to collect and identify effective predators of leafminers attacking vegetable crops and determine the effect of the construction of breeding chambers for predatory flies on LM damage in string beans.

Predators with emphasis on predatory flies were collected from different vegetable growing areas in Central Luzon. Collected predators were initially tested in the laboratory to confirm their predatory habits. A breeding chamber was constructed near a field planted with string beans. Damaged leaves were compared between a field near the breeding chamber and a field about 100m away but without the breeding chamber. The field without the breeding chamber was sprayed with insecticide. The chamber measured 1 x 1m and was 20cm high. It contained a mixture of soil, ground coconut husk including the fiber, rice flakes and water was added to keep the chamber moist.

Field collections of adult flies, which are suspected to be predators, were started and the flies were introduced into a mylar cage with prey. However, no predation was observed. This could be attributed to limited space in the mylar cage or to samples collected. Some of the flies were preserved in 70% alcohol for future reference and identification.

The study on string beans was set in two plots set about 100 meters apart to eliminate insecticide drift from the treated plot. Damaged leaves due to leaf miners and parasitism of larvae were counted and recorded from both treatments. The number of damaged leaves on string beans was high during the early stage of crop growth. However, there were slightly more damaged leaves in the sprayed field compared to the unsprayed, except at 46 days after transplanting (DAT).

Totals of 310 and 362 LM larvae were reared from sprayed and unsprayed fields, respectively. These larvae were collected three times at weekly intervals during the fruiting stage. This was done by collecting leaves bearing the larvae, placed in rearing jars, until parasitoids or adult LM emerged. Larval parasitism ranged from 1.8-26% (mean – 17%) and 1.8-28% (mean 16%) in sprayed and unsprayed fields, respectively. Results indicated that application of insecticide in string beans had little effect on the level of larval parasitism.

Eight species of parasitoids emerged from the larvae reared in the laboratory, seven of which were identified and one which was not. *Diglypus isaea* (Walker) was the most common parasiotid, followed by *Asecodes delucchi* (Boucek), *Hemiptarsenus variconis* (Girault) and *Neochrychollis okazakii* Kamijo. Others were recorded in low numbers (Figure 7). Results show that the presence of a breeding chamber of the predatory fly had little effect on the damaged of LM in string beans, larval and larval parasitism.

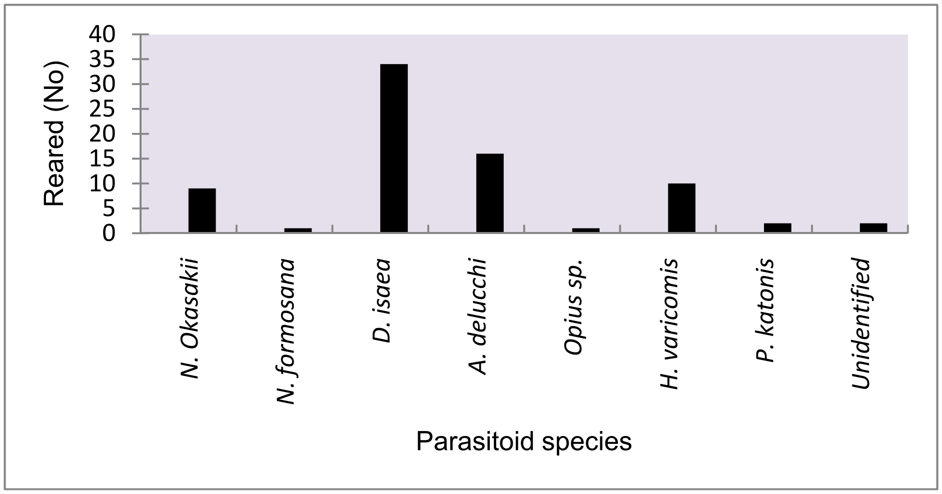

Figure 7: Abundance of the different species of parasitoids reared from string beans. CES PhilRice, 2009 Season.

Field evaluation on the use of sticky board traps and naturally occurring beneficial organisms for leafminer management

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

Effective management of pests is critical in enhancing productivity. Due to the increasing interest of stakeholders to address the concerns associated with the misuse of pesticides, application of alternative pest management strategies such as biological control has become popular especially in vegetables. Besides being economical due to the abundance of naturally occurring beneficial organisms, biological control is safe and poses little or no danger to the environment.

The study hopes to develop and promote the use of non-chemical technologies for the management of leafminers attacking vegetables and other crops. Conservation of naturally occurring beneficial organisms by need-based and selected use of insecticide spray and the use of yellow sticky board traps for trapping of leafminer adults were evaluated in the field.

Leafminer damage in onion

The study was conducted at the Central Experiment Station, Philrice from the later part of 2008 through the dry season of 2009. The treatments included plots with yellow sticky board traps and without yellow sticky board traps. Due to limited area planted in onion at the station, only two replicates were made per treatment. Trap catches were counted weekly, at the same time, traps were cleaned and new adhesive was applied.

Catches of leafminer adults on yellow sticky board traps are shown in Figure 8. Adult flies were first recorded at 25 days after transplanting (DAT) with a peak in catches recorded at 39 and 60 DAT. Damaged leaves (%) were significantly lower in fields with yellow sticky board traps as compared to insecticide treated plots in all sampling occasions. It is evident that the trap could be incorporated in the management of leafminer in onion.

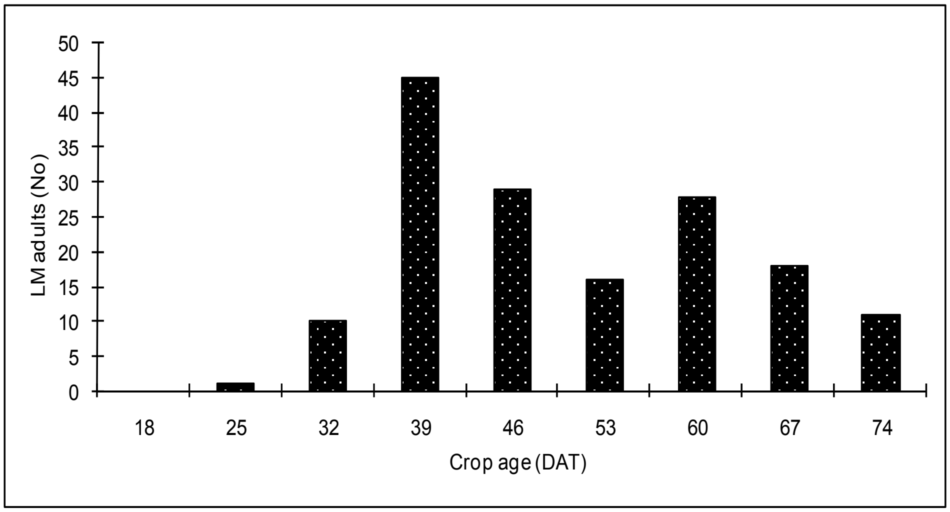

Figure 8: Catches of leaf miner adults on yellow board traps in onion field. CES, Philrice. 2009

Evaluation of sex pheromone baited-traps as a tool for effective timing of intervention against *H. armigera* in tomato

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

The tomato fruit worm is an important insect pest of corn and other vegetables. Farmers normally spray their crops when damage is observed in the field, especially in tomato. However, when the larvae are inside the fruits, insecticide spray cannot reach the target insect and in most cases, spraying is wasted. Therefore, proper timing of application of intervention is critical for an economical and successful management strategy against this pest.

Results of our 2008 study showed that the peak in number of eggs occurred at almost the same time as the number of males caught in the sex pheromone baited traps. This indicated the possibility that sex pheromone-baited traps could be used as a monitoring and surveillance tool for effective timing of intervention against *H. armigera* in tomato.

One-month old tomato seedlings were transplanted in the field inside the PhilRice Central Experiment Station (CES). Three sex pheromone-baited traps for *H. armigera* were installed immediately after transplanting. There were 5 treatments replicated 4 times in a randomized complete block design. The treatments are the following: T1- weekly spray of insecticide, T2- Spray 3 days after a peak in catches of male moths, T3- Spray 5 days after peak, T4- spray 7 days after peak and T5- Untreated control. There were a total of 20 plots each measuring 4m X 5m. Sex pheromone traps were counted and recorded 3 times a week and sex pheromone dispensers were replaced every month. Tomato fruits were harvested as needed. Number and weight of healthy and damaged fruits were recorded during harvest. Damaged fruits were dissected and numbers of *H. armigera* larvae were recorded.

Catches of male moths in sex pheromone-baited traps is shown in Figure 9. Three peaks in the number of male moths caught in the traps were recorded at 13, 35 and 56 days after transplanting (DAT). The peaks were used as the basis for insecticide applications in treatments 2, 3, and 4. Therefore, these three treatments were sprayed 3 times during the crop period. On the other hand T1 was sprayed 11 times. The incidence of tomato leaf virus was noted as the crop matured and it was decided that harvesting be terminated after 85 DAT. This limited our harvesting and yield data to 70, 75 and 85 DAT.

Highest yield based on number and weight of healthy fruits were recorded in the weekly sprayed plot (T1) and in plots sprayed at 7 days after peak in sex pheromone trap catches (T4). Lowest yields were recorded in T2, T3, and untreated control (T5). The untreated control had the highest weight of damaged fruits recorded while the weekly sprayed field had the lowest. A similar trend was recorded on the number of larvae dissected from damaged fruits per treatment. The control plot had the highest number of larvae collected and T1 had the lowest. Based on the number and weight of healthy fruits, the weekly sprayed plots were comparable with the plots which were sprayed at 7 days after the peak in male moth catches. It could be that this is the best time when intervention is needed to reduce damage due to *H. armigera* in tomato. This study will be repeated next season for more conclusive results

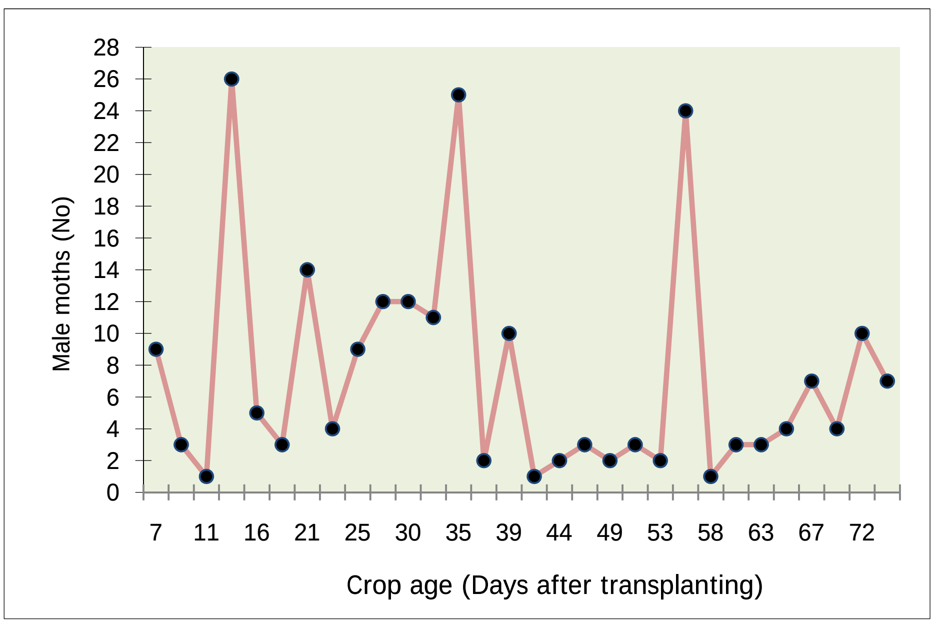

Figure 9: Catches of male *H. armigera* moths in sex pheromone traps

Comparison of sex pheromone and light trap catches

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

Catches of *Spodoptera litura* and *S. exigua* in the sex pheromone baited trap and light trap are shown in Figure 10. The light trap was not able to collect adults of the two species considered. Hence, sex pheromone baited traps are more effective than using light trap in monitoring the population of the pests in the field.

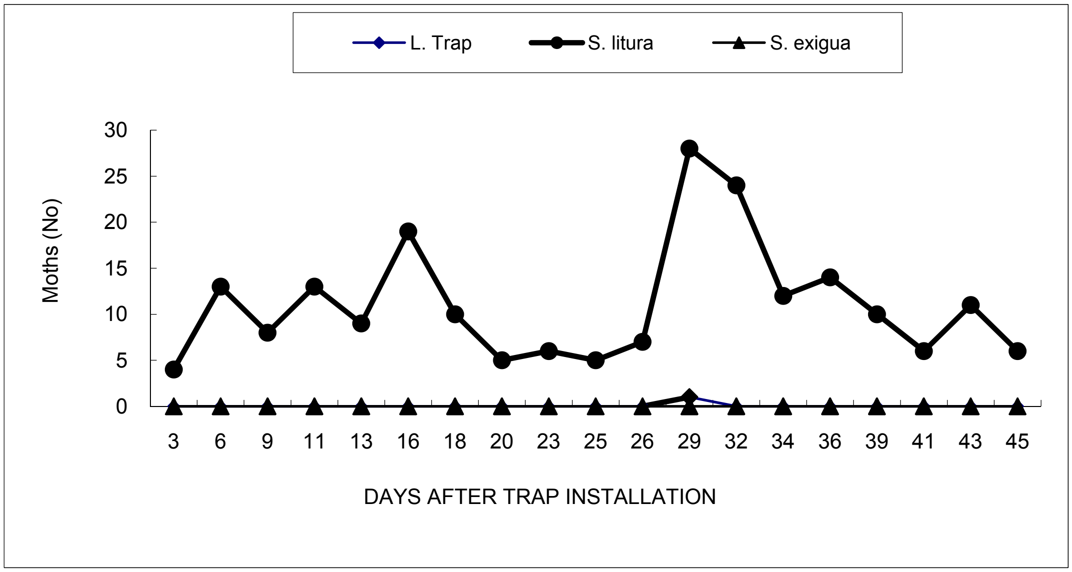

Figure 10: Catches of male moths in sex pheromone and light traps. CES, Philrice (2009)

Mulching for managing whitefly (*Bemisia* sp.) on melon

A.C. Roxas, M.G. Patricio, H.R. Rapusas and B.M. Shepard

Mulching is a very important step in growing healthy plants. It helps to conserve moisture in the root balls of new plants until the roots have grown out into the surrounding soil. There are several kinds of reflective mulch commercially available. These include aluminum and silver polyethylene plastic. Several studies on the efficacy of reflective mulch have demonstrated. It was found effective in confusing and repelling aphids, thrips and whiteflies. Reflective mulch is commonly used in vegetable production. Though it is an added cost in vegetable production, the cost incurred can be compensated from the increase in yield and at the same time cost of labor in the maintenance of the area is reduced.

Different colors of polyethylene plastic mulch and rice straw were used in the study to evaluate their repellency to whitefly population in melon and to determine percentage incidence of viral diseases when plants are mulched with silver and yellow polyethylene mulches in comparison with rice straw mulch.

Number of whiteflies, *Bemisia tabaci*

Results show that the plot mulched with yellow polyethylene consistently contained the lowest whitefly population (Table 11). However, at 24-38 DAT the populations of whiteflies in both the plot mulched with yellow and the plot mulched with rice straw were similar and significantly lower compared to the control plot.

Table 11: Number of whiteflies (*Bemisia tabaci)* based on 3- l20 sample plants as affected by different treatments

Treatment	Number of Whiteflies						Cumulative number of whiteflies
	10 DAT	17 DAT	24 DAT	31 DAT	38 DAT	46 DAT	
Yellow mulch	12.00 [d]	6.33 [c]	14.33 [c]	13.67 [c]	8.33 [c]	21.33 [c]	76.00[c]
Silver mulch	78.00 [a]	36.33 [a]	33.33 [ab]	33.00 [ab]	35.33 [a]	23.67 [c]	239.67[a]
Rice straw mulch	29.33 [c]	27.00 [b]	24.33 [bc]	23.67 [bc]	16.67 [bc]	41.33 [b]	163.00[b]
No mulch (control)	53.00 [b]	40.67 [a]	36.67 [a]	36.00 [a]	27.00 [ab]	64.00 [a]	257.33[a]

Means in columns followed by a common letter(s) are not significantly different at 5% level by DMRT.

Number of cucurbit worm, *Diaphania indica*

Counts of cucurbit worms revealed that mulching of plastic polyethylene of different colors and rice straw mulch did not affect the population level of cucurbit worm.

Plant vigor rating

Presented in Table 12 is the plant vigor rating, as affected by the different colors of mulching materials used. Results showed that plants grown in plot mulched with yellow polyethylene significantly grow significantly more vigorously at 10 DAT. However, at 17 up to 38 DAT, plant vigor rating was similar for all types of mulch, but significantly more vigorous compared to the control plot.

Table 12: Plant vigor rating as affected by different treatments

Treatment	Plant vigor				
	10 DAT	17 DAT	24 DAT	31 DAT	38 DAT
Yellow mulch	4.33 [a]	4.67 [a]	4.67 [a]	4.00 [a]	3.67 [a]
Silver mulch	3.00 [b]	3.67 [a]	4.00 [a]	4.00 [a]	3.33 [a]
Rice straw mulch	3.00 [b]	3.67 [a]	4.00 [a]	3.67 [a]	3.33 [a]
No mulch (control)	2.00 [c]	2.00 [b]	2.33 [b]	2.33 [b]	2.00 [b]

Means in column followed by a common letter(s) are not significantly different at 5% level by DMRT. Rating Scale = 1-5. DAT – Days after transplanting

Number and weight of marketable fruits

Plants grown in plots mulched with yellow and silver plastic polyethylene had significantly higher number of marketable fruits, 30.22 and 30.44 tons/ha respectively compared to plants grown in plot mulched with rice straw and the control plot with 23.11 and 16 tons/ha respectively. On the other hand, plot mulched with rice straw had significantly higher numbers than untreated plot (Table 13).

In terms of weight, plots mulched with yellow and silver produced significantly heavier weight of marketable fruits compared to weight of fruits harvested from plot mulched with rice straw and the control plot, but the weight of fruits harvested from plot mulched with rice straw was significantly higher compared to the control plot.

Number and weight of non-marketable fruits

The number of non-marketable fruits was not significantly affected by the treatments evaluated. However, in terms of weight, plots mulched with yellow plastic and rice straw similarly gave heavier weight of non-marketable fruits compared to the rest of the treatments.

Table 13: Number and weight of marketable and non-marketable fruits as affected by different treatments

Treatment	Marketable fruits/plot		Non-marketable fruits/plot		Computed yield/ha
	Number	Weight (kg)	Number	Weight (kg)	
Yellow mulch	35 [a]	27.2 [a]	16 [a]	7.70 [a]	30.22 [a]
Silver mulch	33 [a]	27.4 [a]	14 [a]	5.70 [b]	30.44 [a]
Rice straw mulch	24 [b]	20.8 [b]	15 [a]	8.03 [a]	23.11 [b]
No mulch (control)	21 [b]	14.4 [c]	13 [a]	5.50 [b]	16.00 [c]

Means in column followed by a common letter(s) are not significantly different at 5% level by DMRT.

Farm women's role in IPM: the case of the Philippines

R. Tanzo and R. Malasa

Farm women are involved in several pest management activities and, in a number of countries, on the average, devote more time to pest management than do men. Given the gender division of labor and differences in access to agricultural technologies, information, and productive resources, the technological needs of women farmers are in many ways distinct from those of men. Farm women need low external input, gender friendly, and time-saving technologies adapted to small areas. The basic principles of IPM are therefore well-suited to such needs. However, few mechanisms, both on the national and international level, exist to incorporate gender issues into the research and development of IPM technologies. Better data on farm women and incorporation of gender issues into IPM research agendas are therefore needed.

Primary data were collected from 162 farm women who were IPM CRSP trainees and wives or female household members of randomly selected male trainees. Three sites were involved in the survey: Nueva Ecija (62 respondents), Nueva Vizcaya (38 respondents), and Ilocos Norte/Sur (62 respondents). A three-page semi-structured interview schedule was used. The questions revolved around six components: (1) farmer and household profile, (2) farm profile, (3) health and IPM, (4) labor for pest management operations in rice and vegetables, (4) technological needs, and (5) training and extension activities. The review of literature, focus group discussions and interview with key informants for the past seasons guided the development of the questionnaire. Enumerators were hired and briefed about the questionnaire before proceeding to the field.

Labor for rice pest management operations were categorized into five types namely, on-farm activities (with eight sub activities), farm decision making (with 12 sub-activities), farm management tasks (with three sub-activities), household tasks (with two sub-activities), and extension activities (with five sub-activities). Degree of participation in labor operations was classified into four categories: regular, occasional, never and not applicable. “Regularly” participating in labor activities meant that the woman did the labor/task most of the time. “Occasional” participation meant that the labor/task was sometimes done by the woman. A “never” response meant that the labor/task was part of the pest management activity of the household but was not done at all by the woman regardless if there was no one else to do it. A “not applicable” response meant that the labor/task was not part of the pest management activities of the household.

Frequency distribution, means, correlation analyses and multivariate analyses were used for data analyses. Farmer, household, and farm characteristics were used to predict women’s involvement in pest management. An analysis of how IPM technologies reach farm women was also made.

Farmer and Household Profile

The mean age of the respondents was 48 years old (Table 14). More than one-third (35%) had reached or finished high school followed by those who had some or finished elementary schooling (31%). A quarter of the respondents had reached or finished college (25%), most of which were from Nueva Ecija. Almost three-fourths (74%) of the women were not members of any farm organization. Nueva Ecija respondents had the highest farm organization membership among the three sites while Nueva Vizcaya had the lowest.

Table 14: Socio-demographic profile of the respondent

Socio-demographic Characteristics	Nueva Ecija			Nueva Vizcaya			Ilocos			Total		
	n=62	%	Mean	n=38	%	Mean	n=62	%	Mean	N=162	%	Mean
Age			48			52			47			48
Educational Attainment												
Some or Elementary Graduate	17	27		11	29		22	35		50	31	
Some or High School Graduate	26	42		13	34		19	31		57	35	
Vocational	3	5		2	5		9	15		14	9	
Some or College Graduate	16	26		12	32		12	19		40	25	
Organizational Membership												
Member	19	31		9	24		14	23		42	26	
Non-member	43	69		29	76		48	77		120	74	

Farm Profile

The respondents had bigger mean farm area for rice (1.41 ha) than for vegetables (0.90 ha). Nueva Ecija farmers had the biggest mean area for rice (1.80 ha). On the other hand, Nueva Vizcaya had the biggest mean area for vegetable (1.19 ha). On the average, the respondents had been farming rice for more than 2 decades already. Nueva Vizcaya posted the highest average in farming experience for rice (24 years). On the other hand, the respondents had been engaged in vegetable farming on the average for 19 years. The difference between the three sites for average years of planting vegetables was not very far off. In each household, there were, on the average, two male and one female members working in the farm. In these households, more than three-fourths of the respondents (78%) owned a knapsack sprayer. A majority of the respondents (62%) were planting both rice and vegetables. Only 3% of the respondents were solely planting vegetables. Also a majority of the respondents (52%) were rice farm owners. For vegetable farmers, the respondents were generally owners (45%) and tenants (32%). It should be noted that Ilocos farmers were generally tenants regardless of crop planted. Nueva Ecija farmers were generally owners followed by tenants.

The major vegetables planted varied in each site. As a whole, the most common vegetables planted were onion (54%) and tomato (26%). Nueva Ecija most commonly planted onion (56%), tomato (22%) and green pepper (19%). Nueva Vizcaya had onion (68%) and tomato (44%) while for Ilocos it was onion (44%), cauliflower and tomato (20% each), and garlic (18%). Ilocos farmers had the greatest variety of vegetables planted with 13 crops.

Health and IPM

When asked if they had experienced any health problems caused by pesticide usage, most of the respondents (89%) answered in the negative. Of those who answered positively, more than half were from Ilocos.

Health problems mentioned were generally short term in nature. Topmost of which were headaches (44%), skin problems (39%), and dizziness (28%). Respiratory-related sickness (dryness of throat, difficulty in breathing, coughing) were common. Note also that most of the health impacts mentioned affected the upper portion of the body or from the throat upwards (dizziness, dryness of throat, headache, eye problems, and sinusitis) Possible long term health impacts of pesticide misuse were not reported by any of the respondents.

Of those who used pesticides, the bulk of the respondents/household (86%) used some form of protective gear. The most common forms of protection used were long sleeves (70%); face mask (51%), and a piece of clothing to shield the face (24%). Ilocos had the highest percentage of farmers using protective gear while Nueva Ecija had the lowest. Most of the protective gear used was to protect the face (face mask, clothing/hanky, sunglasses, cap and goggles). Based on field scoping, face (or dust) masks are lightweight, disposable and affordable (P10 – 15 or $0.20 - 0.25 each). Long sleeves were usually cotton or of light weight materials.

Disposal of pesticide containers was usually around the house/farm area only. Almost one-third of the household either sold (30%) or buried/left the pesticide containers on the farm (29%). Unlike in Nueva Ecija and Nueva Vizcaya, Ilocos farmers usually buried the pesticide containers in their backyard which were sometimes picked up by the garbage collectors (39%).

Labor for pest management operations in Rice

The on-farm activities with high participation by the women were hand weeding (28%), rice hull burning (22%), and in regular monitoring of the field (22%). On applying pesticides using hands and installing traps, the participation of women were very low (1-7%) because those activities were not actually part of the on-farm activities of the household in pest management. More than half of the women respondents did not participate in the following on-farm activities: spraying pesticides (79%), flooding to control pests (59%), regular monitoring (52%) and rice hull burning (52%). Note that installing traps (74%) was not practiced by majority of the Ilocos farmers. Spraying pesticides, an activity thought to be done by male farmers only, was being performed by the women regularly (1%) and occasionally (6%).

With regards to farm decision-making, the women were more active. A majority of the women contributed regularly in the allocation of money for pesticides (75%), whether to use synchronous planting (50%), what or whether to engage in crop rotation (45%), in the purchase of pesticides (32%), and in deciding to use resistant varieties (31%). The least regularly participated activities with regards to farm decision-making were in the use of beneficial organisms (8%), the proper timing of pesticide application (10%), and the use of less toxic pesticides (17%). Looking at the sites individually, certain participation was observed to be unique for each site. For Ilocos, there were three farm decision making activities that more than half of the women regularly participated in. These were in the use of synchronous planting (50%), use of early maturing varieties (55%) and use/assignment of storage rooms for pesticides (56%). For Nueva Vizcaya, there was a high participation of women in the decision to use less toxic pesticides (38%) which was not true for the other two sites. The percentage climbed to 56% when the "occasional" participants were added.

In relation to farm management tasks, the women's participation in the three sub-activities was minimal. It was only in the record keeping of pesticide use (20%) that they participated most regularly (Table 15). Note however, that these activities were generally tasks not part of the household pest management activity as shown in the high percentage of "not applicable" responses.

Table 15: Participation of women in farm management tasks in rice related to pest management

Activities	NE		NV		Ilocos		Total	
	n=61	%	n=34	%	n=62	%	n=157	%
Record keeping of pesticide use								
Regular	16	26	11	32	4	6	31	20
Occasional	4	7	2	6	6	10	12	8
Never	20	33	3	9	13	21	36	23
Not Applicable	21	34	18	53	39	63	78	50
Record keeping of pest occurrence								
Regular	-	-	4	12	2	3	6	4
Occasional	3	5	1	3	2	3	6	4
Never	23	38	2	6	5	8	30	19
Not Applicable	35	57	27	79	53	85	115	73
Income generating activities								
Regular	-	-	2	6	1	2	3	2
Occasional	2	3	-	-	1	2	3	2
Never	16	26	5	15	8	13	29	18
Not Applicable	43	70	27	79	52	84	122	78

Women generally participated regularly in household tasks connected to pest management labor. Foremost of these was the separating and washing of pesticide soaked-clothes (75%). Storing pesticides away from water sources and food was regularly participated in by more than half of the women (52%).

Regular participation of women in extension activities in rice related to pest management was not very high (3 to 12%). Occasional participation in these activities was a little higher (3 to 22%). Holding key leadership position in IPM groups was not part (58%) or never participated in by women (36%).

Labor for pest management operations in vegetables

On-farm activities for vegetables related to pest management had varied levels of participation from the women respondents. Like in rice, hand weeding had the highest regular (41%) and occasional (30%) participation from women. The task of spraying pesticides was done by very few women (3%) but the percentage increased when asked if it is occasionally done (10%). Applying pesticides by hand was occasionally done by only one woman who is from Nueva Ecija. Installing traps for pests, an IPM activity taught by the CRSP, was not very popular based on the high percentage of "never" (44%) and "not applicable" (49%) responses.

With regards to farm decision making, a majority of the women (73%) regularly participated in the allocation of money for pesticides. About half contributed regularly to deciding on issues related to crop rotation (50%) and synchronous planting (46%). The decision to use beneficial organisms and proper timing of pesticide application (8% each) had the lowest regular participation of women.

In terms of farm management tasks, a quarter of the women were regularly keeping records on pesticide usage. Women were hardly ever involved whether regularly or occasionally in keeping records on pest occurrence (3-6%) and engaging in income generating activities in the production of biocontrol agents (2-3%). Note however that these two activities were not really part of the pest management activities of the household.

With regards to household tasks, almost three-fourths (84%) of the women were regularly involved in the separating and washing of pesticide-soaked clothes. Storing pesticides away from water and food (58%) were being done regularly by more than half of the respondents.

Participation of women in extension activities related to pest management was minimal. For the five sub-activities, regular participation was only in the range of 4-11% (Table 16). Occasional participation was a bit higher (2-23%). Among the three sites, Nueva Vizcaya women respondents were the most active in the five sub-activities. The sub-activity "holding key leadership position in IPM groups" was the least participated in by women.

Technological needs

The women were asked what characteristics they consider important when they adopt a pest management technology. As this question was only added in the latter part of the survey, only the Nueva Ecija and Nueva Vizcaya respondents answered the question.

The topmost characteristics mentioned were low cost (57%), safe to use (34%), effective in managing the target pests (26%), and easy to use (23%). Note that some respondents did not give any response (1%) and others have no idea what IPM is all about (24%).

Table 16: Pest management technological needs of women farmers in Nueva Ecija and Nueva Vizcaya

Characteristics	Nueva Ecija		Nueva Vizcaya		Total	
	n=62	%	n=38	%	n=100	%
Low cost	31	50	26	68	57	57
Easy to use	12	19	11	29	23	23
Safe to use	14	23	20	53	34	34
Effective in managing the target pest	11	18	15	39	26	26
Can be easily taught to other household members/co-farmers	5	8	7	18	12	12
Can generate extra income	3	5	3	8	6	6
Can be done by both men and women	1	2	2	5	3	3
Can be used on several pests	7	11	2	5	9	9
New technology	2	3	-	-	2	2
Increase yield	8	13	-	-	8	8
No idea on IPM	21	34	3	8	24	24
No response	-	-	1	3	1	1

Training and extension

Most of the respondents (76%) had never attended an IPM-related training (Table 17). For those who had attended an IPM training, these were generally short term (91%) and all were conducted by government agencies (100%). Most of the training was on IPM (49%) and rice production (28%) There was training on vegetable production but these were conducted side by side with rice production.

Table 17: Attendance in IPM training

Particulars	Nueva Ecija		Nueva Vizcaya		Ilocos		Total	
	n=62	%	n=38	%	n=62	%	N=162	%
Attended Training	18	29	13	34	8	13	39	24
*Trainings**								
Rice Production	2	11	9	69	-	-	11	28
Onion Production	4	22	2	15	-	-	6	15
Rice-veg-onion Production	1	6	-	-	1	13	2	5
IPM	6	33	6	46	7	88	19	49
Rice-veg Production	5	28	-	-	-	-	5	13
Rice-onion Production	1	6	-	-	-	-	1	3

n=number of farmers in the area

After attendance of IPM-related trainings, most of the respondents reported positive changes. They reduced pesticide application for rice and vegetables (78% and 74% respectively), their yield had increased (62% and 52%), their confidence when talking to agricultural technicians about pest control had improved (84% and 83%), family members valued their opinion about pest management more (73% and 74%), and their decision making authority in pest management had increased (49% and 52%). (Table 18).

Table 18: Changes after IPM training in vegetable

Changes	Nueva Ecija		Nueva Vizcaya		Ilocos		Total	
	n=9	%	n=8	%	n=6	%	n=23	%
Frequency of pesticide application								
Reduced	6	67	7	88	4	67	17	74
Increased	2	22	-	-	1	17	3	13
No change	1	11	1	13	1	17	3	13
No response	-	-	-	-	-	-	-	-
Change in yield/production								
Reduced	1	11	1	13	-	-	2	9
Increased	3	33	6	75	3	50	12	52
No change	5	56	1	13	3	50	9	39
No response	-	-	-	-	-	-	-	-
Confidence when talking to agricultural technicians								
Reduced	1	11	1	13	-	-	2	9
Increased	6	67	7	88	6	100	19	83
No change	2	22	-	-	-	-	2	9
No response	-	-	-	-	-	-	-	-
How household members value their opinion								
Reduced	-	-	-	-	-	-	-	-
Increased	5	56	6	75	6	100	17	74
No change	4	44	2	25	-	-	6	26
No response	-	-	-	-	-	-	-	-
Decision-making authority								
Reduced	-	-	-	-	-	-	-	-
Increased	4	44	3	38	5	83	12	52
No change	5	56	5	63	1	17	11	48
No response	-	-	-	-	-	-	-	-

For those who had not attended IPM-related trainings, primary reasons given were being busy with household chores (39%), busy with family (26%) and busy with job/business (19%).

Conclusion and Recommendation

Extent of women's participation in pest management and their contribution to IPM

Considering their pest management roles and pesticide safety practices, women can contribute a lot to the generation and implementation of IPM technologies.

First, as major hand weeders for rice and vegetables, women's knowledge and experience should be considered in the implementation of weed management for these crops. These women should serve as key informants if a new technology on weed management is being developed. Trainings on weed management should have women participants. Likewise, their opinion and experience should matter when weed technologies are assessed. They will be in the position to inform researchers if the weed technology will help ease their work, displace them, or will be acceptable.

As participants in field monitoring for pests in rice and vegetables, what women have observed and learned from this activity should be valuable inputs in improving this IPM task. They may have acquired important local knowledge toward the understanding of pest behavior. It may be worthwhile to have focus discussions with women on this activity as they may have developed a system on how to better accomplish the task or ideas on how to improve the activity. In addition, how they are able to manage and balance multiple tasks, especially tasks that are detail-oriented, is a skill that IPM will profit a lot from.

Being a key person in allocating money for pesticides, women's financial decision making should then be considered in the promotion of IPM technologies. An IPM technology will have a higher chance of being adopted if it fits women's know-how in budgeting. Informing women of the many dangers of pesticide misuse may have impact on managing the pesticide practices of the farm household. They will likely be major supporters of IPM. Filipino women are the main health caretakers and thus will be more conscious to support health-friendly activities. They may act as IPM allies in pushing their husbands and other farm household members to use pesticides properly. They will be more careful when they wash pesticide-soaked cloths, and more vigilant in keeping and disposing of pesticides. Thus, in effect, they will be lessening the likelihood of pesticide poisoning in the household.

With their high participation in decision-making related to pest management, it is therefore imperative that women are also invited to IPM training and that their inputs in technology development be considered. The fact that they have a say in what pest management to use for rice and vegetables means that they have local or stored pest management knowledge that the household considers important. If their local or stored knowledge on pest management is captured, this may contribute in coming up with gender-appropriate pest management technologies. In addition, if this knowledge is improved based on capacity enhancement then, the farm household is benefited more. It has always been proven that previous studies that an investment in women is tantamount to improving the health and economic status of the household.

Technological needs of farm women in IPM

The data showed that when it comes to women farmers, several technological characteristics were considered in choosing a pest management option. Economics and safety issues were paramount to these farmers which mirror Filipino women's roles as the family's treasurer and health caretaker. More importantly, these technological characteristics are compatible with IPM. Considering women's roles in IPM, their technological needs and the principles underlying IPM, tying all these together is a win-win situation for women farmers and IPM. IPM programs developed with a consideration of Filipino women farmer's situation will most likely have a higher rate of household adoption.

Diffusion of IPM technologies to women

Attendance at IPM-related trainings and participation in extension activities was very low for women farmers regardless of the fact that the majority of them, as the data showed, are involved in pest management. Various reasons were cited by the women for non-attendance. For those who did, most of the respondents reported positive impacts. The poor reach of IPM to women should be a challenge for IPM extension, with much consideration of the reasons why women were not able to attend. The usual reason for non-attendance has to do with household responsibilities of women – this should be considered by IPM for better adoption. Information on what PPEs (personal protective equipment) to use during pest management activities did not seem to reach the women and their household. Or looking at it from another angle, it is possible that there has been very little training on such topics. These should be considered by IPM. If it cannot be incorporated in the training, knowledge products should be disseminated in the areas. The installation of pest traps, one of the technologies forwarded by the CRSP in the sites, were not popular among the households or among the women. Reasons for such behavior should be surveyed and results fed back to the researchers.

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

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Introduction of local nectar plants into vegetable farming systems

Ten species of nectar plants were introduced into existing farming systems in various agro-ecological zones of Tajikistan and Kyrgyzstan in collaboration with farmers and NGOs.

Based on results of the prior studies on the attractiveness of 26 species of nectar plants to natural enemies in Tajikistan and Kyrgyzstan, 10 most effective plant species for inclusion in farmer field trials selected were dill, coriander, marigold, interrupta, sweet basil, balsam, pyrethrum, fernleaf yarrow, horse mint, and sweet fennel.

Selected nectar plants were introduced into existing vegetable farming systems in Hissor and Kulob regions of Tajikistan and in the Isiqul region of Kyrgyzstan in collaboration with NARS and local farmers. In addition, nectar plants were also introduced into cotton fields in the Hissor region of Tajikistan. Specifically, mixed nectar plant strips (100 m long and 2.4 m wide) were setup in two vegetable crop fields and one cotton field.

The main objective was to demonstrate to farmers the advantages of flowering plant strips for natural enemy conservation and their impact on pest suppression in vegetables and cotton through a Farmer Field School approach. The study demonstrated that flowering plants attract large numbers of natural enemies in comparison to control fields. The most abundant natural enemies included: *Coccinellidae, Nabidae, Anthocoridae, Syrphidae, Tachinidae, Chrysopidae, Vespidae, Sphecidae, Ichneumonidae, Braconidae, and Chalcidoidea.*

The concept of landscape ecology and biodiversity was extended to farmers and other stakeholders through a training program and two Farmer Field Days to show farmers the advantage of biological control approaches in comparison to chemical methods.

Efficacy of *Amblyseius mckenziei* against *Tetranychus urticae* in cotton

Predatory mites of the family Phytoseiidae fauna are common generalist predators in many agroecosystems, but little attention has been paid to their potential as biological control agents.
Tetranychus urticae (Acaria: Tetrastichidae) is one of the main pests of cotton in Central Asia. In Uzbekistan, it develops on cotton in the summer and outbreaks become apparent in July-September at the flowering stage until defoliation.
Field trials were conducted in September 2008, in Andijan Province on a 500 m^2 cotton field during the time cotton plant was in the flowering stage to boll formation. Spider mites were scouted on a 1 ha area on the field, the number of spider mites per 1 m^2 was determined to be 150 -170, a level 1 infestation (>25% leaves damaged). The field was then divided into 6 by 100m^2 plots. The predatory mite, *Amblyseius mckenziei* (*Neoseiulus barkeri)* (Hughes) was reared in the laboratory on *Acfrus farris* (flour mite) for the field release. The releases were made at different predator:prey ratios as follows: 1:2, 1:5, 1:7, 1:10, and 1:20, with an

equivalent use rate of 7500, 5000, 2100, 1500, and 1000 per $100m^2$. Field monitoring was conducted randomly with the leaves of one plant carefully inspected with a 20X magnifier at every 10 meters. Some leaves were collected at the same time for further examination in the laboratory under a binocular microscope. Data were analyzed using analysis of variance in MS Excel.

We estimated the optimal predator: prey ratio to be 1:7 and 1:10, with an equivalent use rate of 25 and 20 predator mites per plant at a pest density of 150-250 individuals per plant. Pest numbers declined 7-10 days following these releases. By the 15th day following release, the number of pest mites was reduced by half, and after 20 days very few spider mites were found. After 30 days, there were no spider mites found in the plots, but the *Amblyseius* predators had also disappeared. Spider mite populations on plants receiving releases at a 1:25 predator: prey ratio reduced to 97 mites/plant after 12 days, 75 mites/plant after 20 days, and very few pest mites were found after 30 days. The best control was achieved by releasing *A. mckenziei* when the spider mite population in cotton fields was very low.

Effect of the predatory mite *Amblyseius cucumeris* on development of the spider mite *T. urticae*

In order to establish a stock culture of spider mite, *T. urticae* were collected from cotton leaves gathered in the Fergana Valley, Rishtan District, in October 2007 and August 2008. Ten kidney beans were planted in the laboratory. When the plants had three leaves, the leaves were randomly infested with spider mites. The mites were counted daily. On the 12th day after infestation, mixed stages of *T. urticae* were transferred onto a rearing unit consisting of an uninfested kidney bean leaf placed on a moistened cotton pad laid on the top of a 0.5 cm sponge in a 15 cm diameter petri dish. The petri dishes were kept in an incubator at 28±1ºC and 60±5% RH. Water was added to the rearing unit when necessary to provide humidity. Predatory mites were transferred to rearing units with a fine brush from a colony maintained on bran infested with *A. farris*, to study longevity and fecundity.

To study the effect of *T. urticae* on the development of *A. cucumeris*, adult *T. urticae* were transferred to healthy kidney bean leaves placed on moistened cotton pads laid on the top of a 0.5 cm sponge in a 15 cm diameter petri dish to maintain leaf vitality. The petri dishes were kept in an incubator set at 28±1ºC and 60±5% RH. Water was added to the rearing unit when necessary to keep the cotton pads moist. Senescing leaves were changed by placing the old leaves with mites on top of new ones. The number of *T. urticae* released was 50 adults per leaf. Then 1, 3, 5, or 10 *Amblyseius cucumeris* females were introduced. There were three replicates per predator density. The experiment was conducted for three generations of *A. cucumeris* development on *T. urticae*.

A. cucumeris developmental time and longevity during the three generations were different (Table 1). *A. cucumeris* had a longevity period of 15 to 20 days for the first generation, 20 to 23 days for the second, and 25 to 27 days for the third generation, demonstrating increased longevity with continued rearing on the same prey. The oviposition period was increased from 9 days in the first generation to 17 days in the second and third generations.

Table 1: Effect of *T. urticae* on the life cycle of *A. cucumeris* at 27 °C during three generations

		Developmental time (days)					
Generation	Number	Egg+larvae	Proto-nymph	Deuto-nymph	Total	Oviposition period (days)	Longevity (days)
First	30±0	3,15±0,1	2,12±0,11	2,65±0,06	7,92±0,31	10±1,73	20±2,65
Second	30±0	2,87±0,06	1,96±0,08	2,42±0,05	7,25±0,17	17±2,65	23±1,73
Third	30±0	2,76±0,1	1,67±0,05	2,53±0,06	6,96±0,21	17±2	27±1,15

Table 2: Average number of eggs laid by *A. cucumeris* females fed on *T. urticae* at 27 °C during three generations.

Generations	**Number**	**Number of eggs laid /female /day**	**Total number of eggs laid /female**
First	30±0	1,96±0,01	17
Second	30±0	1,67±0,58	21
Third	30±0	1,77±0,69	27

Mean number of eggs laid by *A. cucumeris* in each generation also differed in subsequent generations (Table 2). During the three generations, all eggs hatched within 1-2 days and the life cycle was completed on average between 6.5 and 7.5 days. Females laid their first egg 2-3 days after adult emergence. The average number of eggs laid per female from the first to third generation was not significantly different per day but increased from 17 to 27 eggs during a female's lifetime. These results suggest that the development of *A. cucumeris* on *T. urticae* greatly improved from first to the third generation during colony establishment.

Development of the predatory mite *A. cucumeris* on pollen grains

From the flowers of sage (*Salvia officinalis*), thyme (*Thymus serpyllum*), camel's-thorn (*Alhagi pseudalhagi*), poppy (*Papaver tatricum*), Mallow (*Malva parviflora*), and the orchard trees cherry (*Cerasus vulgaris*), apple (*Malus domestica*), and apricot

(*Prunus armeniaca*), anthers were collected during spring and summer of 2007 and 2008, and taken to the laboratory of the Botanical Institute of the Uzbek Academy of Sciences. Anthers were spread out on a paper and air-dried for 3 days. The pollen grains were then separated from the anthers by sieving through 1 mm plastic mesh, then placed in 1.5 ml glass vials and stored at approximately –20ºC. Bee pollen was bought in the commercial market and cleaned of debris with 1 mm plastic mesh and then treated in an oven for 3 hours at 60ºC.

Three liter jars containing 300g of bran were inoculated with 500 flour mites (*Acfrus farris*) and 100 *A. cucumeris* for the experiment. To determine development and survival ability of the predator, 100g of bran with 1g of each type of pollen was placed in 1l jars every day. Then 100 flour mites, and 50 adult female *A. cucumeris* were introduced and maintained at constant laboratory conditions of 27ºC, 65±5% RH, and 16L:8D photoperiod in growth chambers. Newly hatched *A. cucumeris* larvae were transferred into 1 liter jars containing 150g of bran and *A. farris*. Every other day 1 mg of pollen grains was added to each 1 liter jar. Thus in the first step, we used two 3 liter jars; in second step, ten 1l jars; and in third step, also ten 1l jars. The developmental stage of all individuals was recorded every 2 hours. Adult longevity was determined by transferring newly molted females and males reared on specific pollen in 1l jars containing 150g bran with grain mites and fed the same pollen as that used during immature development. The number of flour mites was calculated by randomly taking samples of bran with pest mites from several places in the container and placing them into the bottle to obtain a total amount of 50cm^3. The bottles with bran and mites were covered with fabric and turned upside down for 10-12 hours. The number of mites gathered on the surface of the stopper is estimated for the flour mites' density in 50 cm^2. The number of predators in the substrate was estimated by counting the number of females in a 3-5 cm^3 sample placed in a Petri dish. *A. cucumeris* survivorship was recorded daily.

Table 3 presents the development time of immature stages of *A. cucumeris*. The developmental times did not differ significantly among the different pollens except for the mallow pollen. The total development time of predators reared with pollens of wild and orchard plants was shorter than for those reared with mallow pollen and on flour mites only. It is possible that not all pollens are suitable supplemental food for *A. cucumeris*. *A. cucumeris* developed from eggs to adult stage faster on sage, thyme, and camel's thorn pollens and significantly faster with pollens of orchard pollens than with mallow and flour mite as food.

Table 3: Mean development time (days) of different stages of A. cucumeris reared on pollen of native fruit orchard plants and bee pollens.

Species	Egg-larva	Protonymph	Deutonymph
Sage	2,89±0,04	1,75±0,12	2,32±0,07
Thyme	2,52±0,14	1,50±0,09	2,24±0,12
Cam.th.	2,66±0,10	1,58±0,04	2,47±0,09
Poppy	2,31±0,09	1,29±0,07	2,15±0,07
Mallow	3,09±0,05	2,05±0,11	2,60±0,03
Cherry	2,07±0,05	1,42±0,10	2,31±0,05
Apple	1,89±0,07	1,14±0,13	2,07±0,08
Apricot	2,09±0,09	1,28±0,07	2,16±0,08
Beepolen	3,04±0,10	1,89±0,04	2,29±0,23
Control	3,11±0,06	2,06±0,06	3,18±0,07

A. cucumeris reared from larva through the adult with pollens of orchard and wild plants as well as bee pollen lived longer than those reared with mallow pollen of mallow plant or on its flour mite prey alone (Table 4). Pollens tested as a supplemental food significantly affected the predator's developmental time and adult longevity. Adult longevity was longer with pollens especially of cherry, apple and apricot than on *A. farris* only.

Our experiment also suggested a significant effect on oviposition of *A. cucumeris* (Table 4) when compared to control (without pollen). *A. cucumeris* oviposition was higher when any pollen was supplied. The maximum number of eggs laid did not exceed one egg per female per day. However, *A. cucumeris* egg and immature production per day increased over 30 days when 1 mg of plant and bee pollen was supplied daily.

Survivorship during immature development was noticeably more when fed on pollen from wild plants. Pollen from thyme, camel's thorn and poppy seemed to improve survival, but greater egg-laying was noted with pollens of thyme, cherry, apple and apricot. *A. cucumeris* survival was increased to 25-33 days in the presence of pollen, confirming that this predatory mite species is indeed a facultative feeder.

Table 4. Longevity, survival and daily fecundity (days) of adult *A. cucumeris* at 27ºC with addition of plant and bee pollens

Species	Adult Longevity	Oviposition	Eggs/day	% Survivial
Sage	26,33±1,53	20,67±2,08	1,23±0,25	98
Thyme	27,33±1,53	28,67±1,53	1,47±0,25	100
Cam.th.	27,67±1,53	21,33±1,53	1,63±0,31	100
Poppy	24,67±2,52	17,67±3,06	1,37±0,15	100
Mallow	19,33±2,52	14,33±2,08	1,07±0,12	93
Cherry	29,33±2,08	25,00±2,00	1,2±0,1	96
Apple	29,67±2,08	25,67±0,58	1,4±0,17	95
Apricot	31,33±1,53	28,33±1,15	1,37±0,15	95
Bee Pollen	23,67±1,15	20,67±1,53	1,47±0,15	97
Control	18,00±1,73	14,33±2,52	1,07±0,12	96

Effect of *A. cucumeris* on whitefly and aphids development in greenhouse vegetable crops

The whitefly *Trialeurodes vaporariorum* Westw (Homoptera: Aleyrodidae) is the most economically important arthropod pest on greenhouses crops in Uzbekistan. It is known to develop pesticide resistance.

The predatory bug *Macrolophus nubilis* and the parasitoid *Encarsia Formosa.*
E. formosa kill immature whiteflies both by laying an egg inside of the nymph, and by piercing the nymph and feeding on its fluids. *M. nubilis* feeds directly on the whitefly nymphs.

Greenhouse field trials were conducted on tomato plants in the Tashkent province of Uzbekistan. Before the experiment, observations were made on tomatoes in plastic plots in the greenhouse to estimate the level of greenhouse whitefly infestation. It was estimated that the whitefly infestation was very low (>1 pest per plant). When the tomato plants were in the flowering stage and approximately 25-30 cm tall *A. cucumeris* were released on an area of 500 m^2 that was divided into 5 plots. The predatory mites were released once a week at rates of 5, 10, 20, or 30 individuals per m^2 in order to establish predator: prey ratios of 3:1, 1:1, 1:2 and 1:1.

The whitefly population density was determined in each row of each plot by examining a top, middle and bottom leaf daily, and collecting 2 leaves per tomato plant weekly. Each leaf was examined under a dissecting microscope, and the number of whitefly eggs, nymphs and pupae were recorded. The experiments were carried out for 35 consecutive days. Analysis of variance was used to analyze the data using MS Excel.

The average number of whiteflies per plant at release ratios of 3:1, 1:2, and 1:1 were reduced relative to the 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 release ratios and in the no release control. The 3:1 release ratio provided the best control in both the laboratory and field trials (Table 5).

Table 5; Changes in the number of whitefly eggs per plant in the greenhouse over time in response to different initial *A. cucumeris* release ratios.

	Number of whitefly eggs/plant			
		Predator:prey ratio		
Days	**Control**	**3:1**	**1:1**	**1:2**
5	5-7	3-7	3-6	5-6
10	15-17	5-7	5-9	7-9
15	25-27	9-11	13-16	19-22
20	33-36	10-12	23-25	27-30
25	53-55	9-11	25-29	33-36
30	72-76	9-11	33-36	47-50
35	95-107	10-12	50-52	51-53

Students Field School

From November 2008 until March 2009, six students from the third year course of agronomical faculty conducted scientific research on the farm of Tazhamatova K.K. under the guidance of Dr. K.E. Ergeshovoj and M. Aitmatov. For general studies, students learn general and agricultural entomology along with the methodology of conducting scientific IPM research. The student's practical training includes conducting experiments on IPM of tomatoes. Students enhance their skills and knowledge along with adults by conducting the experiments, supervising certain aspects, discussions and decision making.

With the knowledge they have gained from their experiments, students will participate in student conferences at a high school in the city of Bishkek in the end of the second year of training. Six students study one day a week at winter SFS on IPM.

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

In the last decade, cereal leaf beetle (*Oulema melanopus*) became one of the most dangerous pests of wheat in Central Asia. During the last several years, researchers at ICARDA have selected different wheat lines with low levels of infestation to this pest. Therefore, the objectives of this study were to identify sources of resistance to cereal leaf beetle to be used in breeding programs to develop resistant cultivars to this pest. This is the second year that the IPM CRSP MSU research program and the Biodiversity and Integrated Gene Management Program (BIGMP) of ICARDA have collaborated on this project. The research plot on "Screening of wheat lines resistance to Cereal Leaf Beetle (CLB)" for 2008-2009 seasons included 130 bread wheat lines with potential CLB resistance and susceptible checks repeated after every nine entries. The wheat seeds were planted November 30, 2008, in a research plot site of Research Institute of Farming "Zemledeliya" of the Academy of Agricultural Science of Tajikistan. The local wheat variety "Sadoqat" was used as the control. The plot size was 1 running meter. The plots with numbers are 246, 446, 301, 501, 646 were culled by reason of bad sprouting.

Spring (March-May 2009) conditions were very humid and cool with approximately twice the normal amount of precipitation, creating favorite circumstances for cereal leaf beetle. Infestations in control plots were high creating the opportunity to clearly evaluate resistant lines. The following lines: Erythrospermum 13\ Erythrospermum 165; Ferrugineum 205\ Frunsenskaya 60 (2 lines); Lutescencs 42\ Odesskaya krasnokolosaya; Intensivnaya\Norin 38\\Krasnovodopadsk; Lutescencs 6300\ Ilichevka\Selinnaya 21; Frunsenskaya 60; Krasnovodopadskaya 210\ Peressvet (2 lines); Erythrospermum 1185\1; Lutescencs 1207\1 (3 lines); Erythrospermum 760\1 showed high levels of resistance to CLB. The lamina of all above mentioned wheat lines were less than 10% infected.

Moderate resistance was observed in the following lines: Erythrospermum8945\Taragi; Erythrospermum6253\2\Stoparka; Erythrospermum13\Erythrospermum 165; Erythrospermum 13\7\Stoparka; Ferrugineum 205\Krasnovodopadskaya 210; Erythrospermum13\Promin; Polucarlik 49\ Krasnovodopadskaya 210\P (2 lines); Albidium 202\2 (only 1 line); Odesskaya (3 lines); Erythrospermum 13\Obriy; Frunsenskaya60\Tardo\ Intensivnaya\Eryt.; Ferrugineum205\ Frunsenskaya 60 (2 lines); Lutescencs 42\Berezina; Polucarlik 49\ Krasnovodopadskaya 210\P.

We intend to continue this study for confirmation in 2009-2010 seasons in Tajikistan.

Baseline survey of pest management practices in Kyrgyzstan, Uzbekistan and Tajikistan.

Wheat, potato and tomato are the key food security crops in Central Asia. The three IPM CRSP research fellows in Central Asia (Dr. Nurali Saidov, Dr. Barno Tashpulatova, and Dr. Murat Aitmatov) conducted a systematic survey of key pests of wheat, potato and tomato in Kyrgyzstan, Tajikistan and Uzbekistan. Using this information, a pest matrix has been developed on these three crops for focusing future IPM research and outreach activities. In addition, the IPM CRSP research fellows inventoried pest management methods and practices used by farmers in these countries. These practices cover: (1) seed treatments,(2) soil treatments, (3) pheromone traps and sticky traps, (4) cultural control, (5) biopesticides, (6) biological control through conservation and/or release of parasitoids and predators, (7) grafting for soil borne pathogens, (8) pest resistant varieties, (9) chemical control, and (10) quarantine measures. This inventory will be utilized for designing IPM Packages for wheat, potato and tomato cropping systems.

Pheromone traps for *Helicoverpa armigera* in Uzbekistan

Dr. Tashpulatova received 10 pheromone traps for *Helicoverpa armigera* from the IPM CRSP HQ which were produced in India at Pest Control Pvt. Ltd. PCI, Division: Bio-Control Research Laboratories (BCRL). In a field experiment, her group tested effectiveness of pheromone traps produced in India in comparison with triangular Uzbekistan pheromone traps made at the Tashkent Institute of Bioorganic Chemistry. The traps from Uzbekistan are traditionally used by farmers in cotton production areas, but are rarely used in tomato crops in any Central Asian countries. Five of the pheromone traps produced in India where tested on 25 ha of tomato fields in Namangan region and 5 on 50 acres in the Tashkent. Traps in the Namangan region were counted from June 25 through July 5, and in the Tashkent region from June 28 through July 20. H. armigera was present in all the tomato fields.

More moths were caught with the traps from India. The average number caught in the first sampling date was 56 individuals, whereas the Uzbekistan traps attracted on average 3 moths per night. However, moths were attracted on only 5-6 days in the pheromone traps from India as compared to 20-23 days for the traps made in Tashkent. The total number of moths caught in the Namangan region with the imported Indian traps was on average 232 individuals, compared to 23 in the local traps (Table 6-9).

Table 6: Attractiveness of pheromones produced in India and in Uzbekistan in tomato fields in the Namangan region

Plot number	Sampling dates										Total	
	26.06.2009		27.06.2009		29.06.2009		30.06.2009		01.07.2009			
	Number of moths per trap											
	Ind*	Uzb**	Ind	Uzb	Ind	Uzb	Ind	Uzb	Ind	Uzb	Ind	Uzb
Plot 1	53	3	57	2	34	5	10	2	7	3	211	18
Plot 2	57	2	59	-	42	2	16	3	6	2	232	11
Plot 3	56	-	60	1	47	3	15	5	5	3	238	15
Plot 4	55	2	53	2	42	-	33	1	9	5	239	13
Plot 5	59	1	57	3	41	1	25	2	9	-	236	8

*Indian pheromones

**The Uzbekistan pheromones producer is Uzbekistan Bioorganic Research Institute, Tashkent, Uzbekistan.

Table 7: Attractiveness of pheromone produced in India and in Uzbekistan in tomato fields in Tashkent region

Plot number	Total # of moths collected in traps in 3 weeks	
	India	Uzbekistan
Plot 1	133	8
Plot 2	161	7
Plot 3	181	6
Plot 4	172	10
Plot 5	207	15

Pheromone traps for *Helicoverpa armigera* in Tajikistan

Ten pheromone traps received from India were set up in Hissor and Kulob region of Tajikistan in cotton and tomato fields. The effectiveness of Indian pheromone traps in comparison to Uzbekistan pheromone traps which traditionally farmers used in cotton areas and rarely in tomato crops in all Central Asian countries was tested. Table 1 shows the attractiveness of Indian pheromones in comparison to Uzbekistan pheromones in the cotton field. The data of pheromones from India showed that a high numbers of moths of American bollworm were caught compared to Uzbekistan pheromone traps.

Table 8: Attractiveness of Indian pheromones in comparison to Uzbekistan pheromones in a cotton field

Number of pheromones in cotton field	Date of set up pheromones in field	Total # of moths collected in traps in 3 weeks	
		India	Uzbekistan
1	17.06.2009	661	18
2	17.06.2009	677	19
3	17.06.2009	682	15
4	17.06.2009	637	13
5	17.06.2009	606	12
6	17.06.2009	583	10

*Indian pheromones

**The Uzbekistan pheromone producer is Uzbekistan Bioorganic Research Institute, Tashkent, Uzbekistan.

Table 9: Attractiveness of Indian pheromones in comparison to Uzbekistan pheromones in a tomato field

Number of pheromones in tomato field	Date of set up pheromones in field	Total # of moths collected in traps in 3 weeks	
		India	Uzbekistan
1	17.06.2009	347	8
2	17.06.2009	339	7
3	17.06.2009	338	6
4	17.06.2009	364	10

Pheromone traps of *Frankliniella occidentalis* in Uzbekistan

Ten blue sticky traps with pheromone received from the IPM CRSP ME to investigate the presence of *F. occidentalis* were placed in tomato fields in the Tashkent region. Observations were made once a day for 10 days. There were no thrips found confirming the absence of *F. occidenatalis* in this region.

Pheromone traps for *Frankliniella occidentalis* in Tajikistan

We received 10 pheromone traps from IPM CRSP ME. In the field experiment, we tested the effectiveness of the pheromone in cotton and in a flowering area (Tables 10 and 11).

Table 10: Attractiveness of pheromones in cotton field in Tajikistan

Number of pheromones in cotton field	Date of set up pheromones in field	Account dates		Total
		19.06.2009	22.06.2009	
		Number of thrips in pheromone traps		
1	17.06.2009	3	2	5
2	17.06.2009	4	2	6
3	17.06.2009	3	2	5
4	17.06.2009	4	1	5
5	17.06.2009	3	2	5
6	17.06.2009	2	1	3

Table 11: Attractiveness of pheromones in flowers field in Tajikistan.

Number of pheromones in flowers field	Date of set up pheromones in field	Account dates		Total
		19.06.2009	22.06.2009	
		Number of thrips per account in pheromones		
1	17.06.2009	15	12	27
2	17.06.2009	17	11	28
3	17.06.2009	18	9	27
4	17.06.2009	14	10	24

We measured the number of thrips attracted to pheromones only twice, because the sheets were fully covered by other insects. Along with thrips, these pheromones traps attracted a number of beneficial insects such as ladybird beetles (*Coccinellidae*), syrphid flies (*Syrphidae*), lacewing (*Chrysopidae*) and others.

Field test of pheromone traps on *Helicoverpa armigera* in Kyrgyzstan. Testing of pheromone traps against *Helicoverpa armigera* was conducted in two areas: Issyk-Kul and in Chui. In Issyk-Kul area, traps were checked daily from July 4-14. In the Chui area, traps were checked July 14-25. The number of moths found in traps was higher in the Chui area (Table 12 and 13).

Table 12: Efficiency of pheromone traps on a tomato field in Issyk-Kuls area in Kyrgyzstan

№ Area with phero-mone on a tomato field	Installa-tion date of phero-mone in the field	Account dates						Total
	3.07. 2009	4.07. 2009	6.07. 2009	8.07. 2009	10.07. 2009	12.07. 2009	14.07. 2009	
Area1	-//-	2	1	2	-	3	2	10
Area2	-//-	4	2	1	3	1	1	12
Area 3	-//-	1	2	2	2	2	-	9

Table 13: Efficiency of pheromone on a tomato field in Chui area in Kyrgyzstan

№ Area with phero-mone on a tomato field	Installa-tion date of phero-mone in the field	Account dates						Total
	14.07.2009	15.07. 2009	17.07. 2009	19.07. 2009	21.07. 2009	23.07. 2009	25.07. 2009	
Area1	-//-	4	3	2	3	2	4	18
Area 2	-//-	3	4	7	4	2	3	23
Area 3	-//-	7	2	1	3	5	1	19

We also tested pheromone for thrips in these areas, however entomologists could not identify the kind of thrips; therefore, we are not reporting it.

Degree Training

Dr. Saidov supervised one post-graduate student in Tajikistan and 3 students for essay graduation level in the Kyrgyz Agrarian University under Student Farm School IPM course program as follows:

- Introduction of nectar plants into existing vegetable farm systems as a method for the conservation of natural enemies in agro-landscapes – 1 post graduate student and 2 students were involved in research with the IPM CRSP program.
- Agro-landscape design – 1 studentwas involved in research with the IPM CRSP program.

Other Training

On September 5, 2009, in Kibray region in Uzbekistan, "Yangiobod Husanov Durbek" farmers' district, the Farmers Association, AVRDC and the IPM CRSP collaborated to conduct a seminar on "Multiplication of new vegetable seeds, and management of diseases and pests on the crops." About 60 farmers and 10 region leaders (mayor, head of farmers association, chairman of farms, director of AVRDC, and others) attended. Among them there were 10 female and 60 male participants. During seminar the opening address was made by Hokim (mayor) N. Myhamedov; Head of the Farmers Association T. Bozorov; and AVRDC Director R. Mavlyanova. Researchers from the Institute of Plant Industry J. Alimov, G. Airapetov, and E. Suleimanov presented a small exhibition, reports and a field demonstration of new vegetable varieties (corn, sunflower and soybean) produced at the institute. Biological disease management was presented by Dr. G. Jumaniazova (Institute of Microbiology). Dr. Tashpulatova made a presentation to the farmers and gave a speech to a radio correspondent about biological control of spider mites and thrips using predator mites, *Amblyseius* sp., and about methods of rearing the entomophages in the biolaboratory. Farmers and other participants were interested in new vegetable varieties, and biological control of diseases and pests in vegetable crops.

On April 30, 2009, five students from SFS have made two reports at the International scientific conference in KAU about the project:

Report 1. Experiences of Field School of Students: The Device and Use of Kinds of Vegetative Hotbeds. Mambetova S., Temirova N., Kerimbaeva A. Students of three agronomical faculty (Ergeshova K.E., KAU senior lecturer, Aitmatov M. ICARDA-IPM CRSP).

Report 2. Experiences of Field School of Students: Influence of Vegetative Pesticides and Stimulators on Growth and Similarity of Various Grades of the Tomato. Karieva E., Abdyrasulov K, N. Ishimova. Students of three agronomical faculties (Ergeshova K.E., KAU senior lecturer, Aitmatov M. ICARDA-IPM CRSP)

Student, Saiakbaeva, a participant of SFS 2007-2008, has successfully passed degree work on a theme: Developing of the students' knowledge of IPM by Students Field School**.**

Transfer knowledge and disseminate information to clients

On November 11, 2008, under invitation of the NGO Ak-Terek, Dr. Aitmatov conducted a one-day training on application of a biomethod and cultivation of sprouts of tomatoes in hotbeds for farmers of NGO "Shoola" in the village Tuura-Suu of Ton district of Issyk-Kul province, Kyrgyzstan. Thirteen people (9 men and 4 women) took part in the seminar. We discussed with advisers of NGO Shoola the potential for joint work and opening one FSF on IPM-tomato together with CTAI. Our project has transferred to NGO Shoola two varieties of tomato and two of pepper, and pheromone against cotton winter scoops from Scientific Research Institute of Vegetables of Uzbekistan. Our project has also recommended growing seeds of vegetable crops in hotbeds using methods distributed during the FSF at KAU developed through the IPM CRSP.

On December 27, 2008, Dr. Aitmatov was invited by NGO "Ak-Terek" to present a day-long training for residents of the village Toluk of Naryn province, Kyrgyzstan. There were 23 farmers (9 men and 14 women) who took part in the seminar. The theme was "Introducting Innovations into Activities of FSF - strengthening agro-landscapes by means of nectariferous plants."

During March 30 - April 3, 2009, Dr. Aitmatov participated in training for trainers by the Aga Khan Foundation in southern Kyrgyzstan. Thirteen trainers (10 men and 3 women) attended. Participants learned skills for group facilitation in teaching IPM approaches.

On March 10, 2009, Dr. Aitmatov organized an exchange experience for trainers of ATC and the Japanese project JAICA from Tajikistan. Visitors were very interested in the kinds of hotbeds constructed for warming vege seedlings. Students of the SFS gave short presentations about their research results at the SFS. Five people from Project JAICA (1 man and 4 women), two representatives ATC, 6 students of KAU (5 women and 1 man), and two farmers (1 man and 1 woman) participated in the session. Participants received leaflets about the three components of the Central Asia IPM CRSP Project.

During the seminar, participants learned the basic approaches and principles of the Center of Training the Trainers.

The official meeting with the director of FAO in Kyrgyzstan, Dr. Sangiba Razhapovich, took place April 8, 2009. We discussed IPP questions and joined KAU in preparations for the project on Phytophthoros of potato. The collaborators in the project, Dr. Anvar Umarovich-trainer (IPM CRSP), KAU scientists and the Agrolead NGO have been involved from Tajikistan. The first variant of the project has been written and has been sent to Tajikistan for completion.

Regional IPM meetings and forums

Tashpulatova. 2008. "Biological control of *Thrips tabaci* (Thysanoptera: Thripidae) using *Ambliseius mckenziei* (Acarina:Phytoseiidae) on onion crop in Kyrgyzstan and Uzbekistan." Conference for the 50th anniversary of Kaz. Scientific Research Institute of Plant Protection and Quarantine, Almaty-Kazakhstan in 2009.

Tashpulatova. 2008. "Studies of the predaceous mites *Amblyseius cucumeris* and *Amblyseius mckenziei* (Acari:Phytoseiidae) in Uzbekistan," Conference on "Application of methods of biological control in agriculture" in Tashkent, Uzbekistan.

Tashpulatova. 2008. "Study of the possibility for introduction and application in Uzbekistan predator mites of the family Phytoseiidae." Conference on "Application of methods of biological control in agriculture" in Tashkent, Uzbekistan.
Saidov, N. Sh. and D.A. Landis. 2009. "Enhancing pest management in organic farming via conservation biological control," The 2nd International Conference on organic sector development in Central/Eastern European and Central Asian countries held in Tbilisi, Georgia. The conference attracted more than 250 participants from 22 countries.

Saidov N. Sh., D.A. Landis, A. Fiedler, V.K. Nazirov, and A. Khalimov. 2008. "The role of nectar plants on attraction natural enemies in agro-landscapes," Conference dedicated to the 60th Anniversary of Department of Biology of National University of Tajikistan in Dushanbe city.

Saidov, N.Sh. and D.A. Landis. 2008, "Landscape ecology and biodiversity to enhance biodiversity and biological pest management". 9th International Conference on Dryland Development, Sustainable Development in the Drylands Meeting the Challenge of Global Climate Change, which was held in Alexandria, Egypt. The conference attracted more than 450 participants from 55 countries.

Third Regional IPM Forum in Central Asia, Spring 2009 in Bishkek, Kyrgyzstan

In order to foster networking and share the research results and experiences of the Central Asia IPM CRSP project, a regional IPM Forum was organized in Bishkek, Kyrgyzstan from June 1-5, 2009. This Third Regional IPM CRSP Forum was co-hosted by the Kyrgyz Agrarian University and the Ministry of Agriculture, Water Resources and Processing Industry in Kyrgyzstan in collaboration with ICARDA-CAC Regional Program. Fifty-eight stakeholders (21 females and 37 males) representing various government research institutions, universities and NGOs from Kyrgyzstan, Tajikistan, Uzbekistan and Kazakhstan attended the forum program in Bishkek. Nine representatives from the U.S. including IPM CRSP Global Program, Michigan State University, University of California Davis, Ohio State University, and Montana State

University attended the forum along with two representatives from ICARDA and AVRDC. This regional forum provided excellent opportunity for networking and information exchange.

The forum program was divided in two parts. The first part included sharing of research results from the Central Asia IPM CRSP program, IPM programs and experiences of various countries in the region, and stakeholders input on enhancing IPM programs in the region, and the second part was a special workshop on pest diagnostics. During the first part, the IPM CRSP team members gave presentations on their research and outreach programs and achievements in: (1) landscape ecology to enhance biodiversity and biological pest management, (2) enhancing the efficiency and product lines of biolaboratories, and (3) development and dissemination of IPM educational and other information in the region. In addition, government and NGO representatives from the region shared information on their IPM activities and approaches to extension/outreach to farmers.

In the second half of the forum (June 3-4), attendees participated in a Pest Diagnostics Training Workshop. The workshop was organized in collaboration with the IPM CRSP Global Theme program on pest diagnostics. Twenty-two participants (10 females and 12 males) from Kyrgyzstan, Tajikistan and Uzbekistan attend this training workshop. The main training facilitators were Dr. Sally Miller (The Ohio State University) and Dr. Barry Jacobsen (Montana State University). Instructors included Dr. Miller (overview, bacterial and viral pathogens); Dr. George Bird (Nematology); Drs. Doug Landis, Mustafa Bohssini and Frank Zalom (insects and mites); and Dr. Jacobsen (fungal plant pathogens and specimen triage). Presentations included information on emerging and endemic diseases caused by fungi, bacteria, viruses, nematodes and insect pests, and beneficial organisms. There is a strong need for pest diagnostic capacity building in the region including training of scientists, extension specialists and laboratory facilities for pest diagnostics.

During the forum program, the IPM CRSP team members met with the Minister of Agriculture in Bishkek and visited Kyrgyz Agrarian University (KAU), IPM Student Field School at KAU, and Kyrgyz-Turkish Manas International University.

Ms. Joy Landis, IPM Communication Specialist from MSU also established a blog documenting the team's travel and meetings in Central Asia in connection with the Forum (see http://www.ipmglobal.blogspot.com/). The blog has received over 420 visitors with more than 680 page views since June 1, 2009.

Short term training at MSU

Mr. Ibroim Sharifov from the Agriculture Training Advisory Center (ATAC) NGO in Tajikistan, and Ms. Aidai Saiakbaeva from the Kyrgyz Agrarian University in Kyrgyzstan participated in the Agroecology, Integrated Pest Management (IPM) and Sustainable Agriculture short course at Michigan State University from June 14-24, 2009. This short course provides training in principles and practices on ecologically based approaches in IPM. The overall goal of this training is to contribute towards building human resources in IPM in Central Asia.

Awards

The Central Asia regional IPM CRSP project has been implemented through the CGIAR/ ICARDA PFU Consortium. This consortium was awarded the CGIAR King Baudouin Science Award for Outstanding Partnership for sustainable agriculture in Central Asia in 2008.

Integrated Pest Management of Specialty Crops in Eastern Europe

Douglas G. Pfeiffer, Virginia Tech

Albania

Developing integrating fungicide control programs to maximize economic return on tomato production in greenhouses.

J. Tedeschini, H. Paçe, I.Papingji, D. Pfeiffer

During the year 2009, the research was conducted in a plastic house located at Rada, a province of Durrës district in the low central part of Albania. The tomato seedlings of cv. Abellus were planted on 10-12 March 09.

In the low cost program, spray intervals were applied at 10 day intervals. This program utilized both organic and synthetic fungicides to control the main diseases (bacterial and fungal diseases). The standard program utilized only synthetic organic fungicides. The standard program was also sprayed on a 10 day interval. The intensive fungicide program mirrored the standard program but sprayed on a 5 day schedule.

Sprays for the intensive program began on 14 April, with a tank mix of Daconil (0.2%) + Acroblu (0.2%), alternated with Equation pro (0.04%) + Teldor (0.1%) every 5 days for a total of 15 applications. Sprays for the standard programs also began 14 April with a tank mix of Daconil (0.2%) + Acroblu (0.2%), alternated with Equation pro (0.04%) + Teldor (0.1%), every 10 days for 8 applications. The low cost program was applied at the same interval as a standard program, but consisted of a Dithane (0.2%) + Kocide (0.2%). In the control the decision for treatments and for the kind of fungicides used were chosen by the farmer. All fungicide sprays were applied with a backpack sprayer. Ten days after the last treatment, 23 June, foliar evaluations were made to determine the percent severity of foliage infected with downy mildew and other prominent diseases. In addition, average fruit weight was recorded.

The fungicide spray records of each treatment were reviewed for economic feasibility and environmental impacts. Because most growers are also concerned with environmental impacts associated with their production practices, Environmental Impact Quotients (EIQ) were assessed for each pesticide used in the spray program. The EIQ values for most pesticides have already been calculated (Kovach et al, 1992) and vary according to their load and eventual fate in the environment. In general, lower EIQ scores result from materials with lower percentages of ingredient and lower field use rates. Over all fungicide treatment combinations there were some differences in average fruit size between the four spray programs and there were also differences in percent foliar infection for gray mold, downy mildew, leaf mold and early blight observed on tomato leaves. The % of severity of these diseases was significantly higher on the low cost and control treatments compared to the standard and intensive fungicide treatment.

At the end of the season, the fungicide spray records for each program were reviewed for economic costs and environmental impacts. Fungicide costs were generated from actual retail cost. If two or more compounds were used in a tank mix, the cost of each component was added together and referred to as the segment cost.

Aside from fungicide costs, growers are concerned with environmental impacts associated with their production practices, specifically pesticide applications. Environmental Impact Quotients (EIQ) are a scientific means of assessing pesticide fate in the environment based on toxicological and environmental data, impacts against arthropod natural enemies, honey bees, and birds, leaching potential, and related human health issues. EIQ values for fungicides used in this study were calculated by Kovach et al (1992). In general, lower EIQ scores indicate products with overall lower environmental impact. Perhaps what is more important than the raw EIQ score is the Field Use Rating (FUR), which takes into account the EIQ score x % active ingredient x rate per ha to get a more accurate picture of environmental impact. When comparing spray programs it is important to realize that the EIQ FUR score needs to be multiplied by the number of applications made over the season to get an accurate overall understanding of environmental impacts. Thus, not always should the product with the lowest EIQ FUR score be chosen over a product with a higher value without first considering how many applications might be necessary to properly manage the pest, or in this case, the disease. It was possible to determine which of these four fungicide programs might be considered “the best” based on lowest disease infestation, lowest cost and lowest environmental impact. Based on these data the best program results the standard program.

Fungicide spay programs affected the percent severity of main diseases tomato leaves. The low cost program and control programs have a significantly higher incidence of infections compared to two other treatments. The control and low cost treatments resulted in significantly more diseases than standard and intensive program.

Evaluation of fungicides for botrytis control of greenhouse tomato

J. Tedeschini, H.Paçe, D. Pfeiffer

Three-week-old tomato seedlings were transplanted into greenhouse soil on 22 February 2009 and arranged in a randomized complete block design with 5 replications (5 rows x 75 plants per row) for each treatment. Serenade (*Bacillus subtilis*), Botrilan (iprodione), Daconil (chlorothalonil) and Pyrus (pyrimethanil) were sprayed onto tomato plants on a 7-10 day schedule for a total of 6 applications. Treatment started on 25 March and ended on 11 May. Severity index of foliar disease was recorded between the applications and after the last application using the modified Horsfall-Barratt scale. Infected fruits were evaluated as percentage on fruits observed.

The 2009 first growing season was relatively wet and cool. The weather was more favorable for foliar diseases. The first appearance of gray mould symptom on leaves was on third week of March. Botrytis was the predominant foliar disease in the trial field. In general tomato gray mold disease pressure was low and no stem cancers were observed. Foliar symptoms included chlorosis and water-soaking at the tip of leaflets and on petioles. In the untreated control ghost spots were observed on green fruits and late stage symptoms included dead leaves and sporulations on senesced petioles and ripening fruits.

The plots treated with fungicides had a lower disease severity on leaves than the untreated control. By the third application plots treated with Daconil, Serenade and

Pyrus have lower disease rating than Botrilan and Control treatment. Severity index of infected leaves after the third application was 1,0, 4,5, 1,0, 1,3 for Serenade, Botrilan, Daconil and Pyrus respectively; whereas that in control it was 6,4. After the fourth application there were significant differences in disease control among treatments. The best efficacy showed Daconil. On May 15, the severity index of infected leaves was 1,5, compared with Serenade (2,1), Botrilan (9,5), Pyrus (2,7) and untreated control (13,8). Compared to untreated control Daconil and Serenade significantly reduced the number of infected ripening fruits. All plots treated with fungicides had lower disease severity than untreated control. By the third application, plots treated with Daconil and Serenade had lower disease ratings than any other treatment. After the fourth application, there were no significant differences in disease control among treatments.

Fungicide resistance management, which seeks to minimize the risk of a plant pathogen population becoming resistant to one or more fungicides, is imperative for the preservation of fungicide effectiveness. Most of all, Daconil must be rotated with other registered products to minimize development of resistance. Serenade, a new biological fungicide seems to be a promising tool of integrated disease management. Only by combining these strategies is possible to maintain the susceptibility of botrytis to Daconil, Serenade and other fungicides used for its management, and to extend their useful lives.

The Efficacy of Soil Treatment with Bio-stimulation Products to Control Root - Knot Nematode on Pepper and Tomato Crops in Unheated Polyethylene Houses

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

Studies for control of root knot nematode (*Meloidogyne incognita*) were performed in plastic greenhouses in the Rada region. Two bionematicides were compared with an untreated control: Softguard (chitosan oligosaccharin) and Nemafung (K_2O plus plant extract). This study was carried out in peppers. Softguard treatment produced the highest yield (171 tons/ha), followed by Nemafung (150 tons/ha), and then the untreated control (132 tons/ha). In a tomato greenhouse, Nemafung treatment was compared with Softguard, with Nemafung resulting in 133 tons/ha, Softguard in 104 tons/ha, compared with 94 tons/ha in the untreated control. In separate study involving lettuce, yields were also increased by both treatments, with 170 tons/ha from Nemafung, 140 tons/ha from Softguard, and 120 tons/ha in the untreated control. Promising results were also obtained in the use of olive pomace and poultry manure amendments for management of root knot nematode.

Evaluation of miticides to control two-spotted spider mites (*Tetranychus urticae*) in cucumber greenhouses

J. Tedeschini, Dh. Shehu, D. Pfeiffer

Table 1: Experiments were established in Kemishtaj (Lushnje region). The following miticides were tested:

No.	Treatment	Commercial Name	Applied Dose
1.	*Beauveria bassiana* 7.2%	Naturalis	100ml/hl
2.	Azadirachtin 10.0g/l	Neemazal – T/S	200ml/hl
3.	Hexythiazox 10%	Nissorun 10 WP	20ml/hl
4.	Spirodiclofen 240g/l	Envidor 240 SC	20ml/hl
5.	Abamectin 1.8%	Abamectine 18 EC	20ml/hl
6.	Absolute control (water)	-----------	----------

The experimental and control plot were part of a commercial greenhouse (Kemishtaj Lushnje) and each consisted of four rows 20m long approximately with a surface of 100m^2. Treatments were established in a randomized complete block design with 5 replications. Five plants/replication about 2m apart were treated until runoff for each product in the trial (Table 1). Product effectiveness was established by estimating the number of mites found before and seven days after treatment. Three leaves from each plant were used for mite counts. The leaves were placed individually in separate paper bags and transported to the laboratory in a cooler. The mortality of mites and eggs were calculated for each treatment and compared with untreated control.

Results proved highly satisfactory as the two-spotted spider mite population was significantly reduced by Envidor 0,02%. As it can be observed in Figure 1, this new miticide caused about 94% mortality against the motile stages compared with standard miticides Nissorun and Abamectine which caused mortality of 91.2 and 87.3%, respectively. Its good profile with respect to beneficial arthropods makes Envidor an excellent tool in integrated pest control in cucumber production. Good results in control of two-spotted spider mite were obtained by using bio-rationale products Naturalis and Neemazal. Naturalis and Neemazal treatments consistently had population that was significantly lower than the control. The level of mortality was 79 and 82%, respectively.

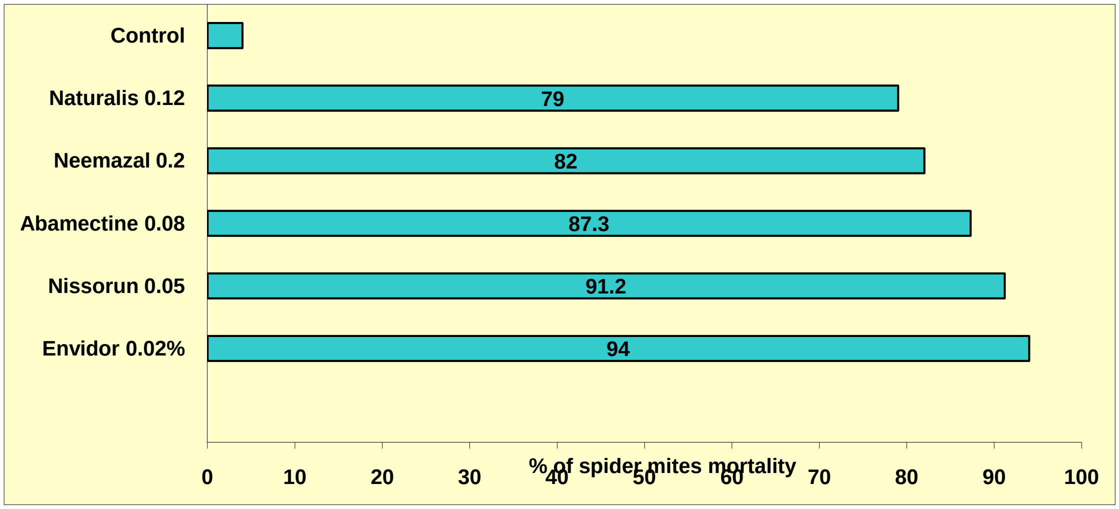


Figure 1: Effect of treatment with miticides against two-spotted spider mites in cucumber, Mullet-Tirane, 2009

The experiment carried out with new miticide Envidor showed good efficacy against the eggs of *T. urticae*, maintaining the number of eggs at a very low level. Its efficacy against eggs is equal to or exceeds that of the best local standard miticide, Nissorun.

In general the field experiments identified botanicals and reduced risk pesticides as an excellent component of an IPM program. Results suggest that a greenhouse integrated pest management program using reduced risk pesticides could effectively and selectively control mite infestations by treating hot spots with negligible effect on biological control agents when treating before introduction or when natural enemies are absent.

Evaluation of botanical pesticides to control whiteflies (*Trialeurodes vaporariorum*) in tomato crops (J. Tedeschini, Sh. Shahini, Dh. Shehu, and D. Pfeiffer)

The study was undertaken during 2009 at Rada, Durrës region to evaluate the effectiveness of several bio-rational insecticides(Table 2) at controlling a glasshouse whitefly infestation on commercial tomatoes. Five products were compared to a water treated control and a commercial standard, Ramplan, for assessing larval control. The products were assessed for controlling adults too.

Table 2: The following botanical pesticides were tested to contol whiteflies.

No.	Treatment	Commercial Name	Applied Dose
	Beauveria bassiana 7.2%	Naturalis	100ml/hl
	Azadirachtin 10.0g/l	Neemazal – T/S	200ml/hl
	Mineral oil 870.0g/l	UFO (ultra fine oil)	1 l/hl
	Natural Pyrethrum (40g/l)	Keniatox Verde	80ml/100 l
	Propylene glycol alginate	Agri-Colle	300ml/100l
	Acetamiprid 20%	Ramplan 20 SP	0,04%
	Absolute control (water)	---------------	-----------

Separate compartments of tomato plants were grown for larval and adult assessment. The plants were naturally infested with whiteflies and at an appropriate time, sprayed to run off point. The effectiveness of the products for controlling larvae was determined by counting the numbers of larvae and empty pupal cases on 25 randomly selected leaves from each of 5 plots of 5 plants per treatment. These numbers were then compared to the water treated controls. The chemical products were applied 3 times during the experiments. The date of application was on 14, 21, and 29 August.

The effectiveness of products at controlling adult whiteflies was evaluated by comparing a pre-treatment adult count on 90 randomly selected leaves for each treatment (14 August) to a post treatment count 3 days after application (17 August). The number of adults/leaf was determined during the assays by evaluating their number on the upper, middle and lower leaves of the plants.

The performance of some products for control of whiteflies is very encouraging. The treatments made against adult whiteflies during 2009 showed different levels of reduction of population density. Three days after treatment, the lowest rate of population reduction of adults per plant was 24.4 % for Naturalis, following with 40.5% for Keniatox (Natural pyrethrum). There was no significant difference in adult mortality between Neemazal T/S, UFO and Ramplan. Neemazal-T/S produced a mortality rate of 61.29% compared with 64% for UFO and 66.7% for Ramplan. The lowest population level of adults per plant resulted after the treatment with Agri-Colle (70% mortality).

The immature population is the best guide of whitefly control. Agri-Colle and Naturalis consistantly resulted in the lowest population level of immature stages. The differences between the standard chemical insecticide Ramplan and Nemazal were not significant. Nemazal, also, 21 days after treatment had a low population level compared with UFO, all the treatments were significant lower than the control. Keniatox had lower efficacy against the immature stages of whitefly.

The proposed insecticides will help reduce the development of pesticide resistance among whitefly populations, as well as extending the effectiveness of many pesticides currently in use. The development of biologically intensive alternatives will also provide growers with an opportunity to evaluate and select non-chemical control tactics for greenhouse crops.

We were interested in evaluating these products for control of adult and larva stages of *T. vaporariorum* taking into account possible repellency and the degree of residual performance. It is anticipated that such products will provide a superior degree of control with no hazards to the environment or worker health and safety. In addition, such products may provide compatibility with natural enemies.

Figure 2: Effect of microemulsion based on rapeseed oil derivatives on whiteflies (*T. vaporariorum*) on tomato.

Agriculture Sector Productivity

Number of new technologies or management practices under research as a result of USG assistance

1. The efficacy of soil treatment with bio-stimulation to control root-knot nematode (*Meloidogyne incognita*) on pepper crop in unheated polyethylene houses
2. The efficacy of bio-stimulation treatment of soil to control root-knot nematode (*Meloidogyne incognita*) on tomato crop in unheated polyethylene houses
3. The efficacy of soil treatment with bio-stimulation to control root-knot nematode (*Meloidogyne incognita*) on cucumber crop in unheated polyethylene houses
4. The integral management of root-knot nematode (*Meloidogyne incognita*) on tomato crop in unheated polyethylene houses with grafted and un-grafted varieties without soil treatment
5. The combination of fresh olive pomace, poultry organic amendments, nematicides, and biostimulation soil treatment to control root-knot nematode (*Meloidogyne incognita*) on cucumber in heated Israeli-style greenhouses
6. Soil treatment and grafting plants as alternative to control, root-knot nematode (*Meloidogyne incognita*) on melon crop in un-heated polyethylene greenhouses
7. Evaluation of bio-fungicide for control of powdery mildew of greenhouse cucumber
8. Evaluation of bio-fungicide for control of powdery mildew of greenhouse tomato

Number of new technologies or management practices made available for transfer as a result of USG assistance

1. Implementation of IPM scouting programs for tomato crop production in greenhouses
2. Implementation of IPM scouting programs for cucumber crop production in greenhouses
3. Effects of soil solarization for controlling soil-borne fungi in plastic tomato houses in Albania
4. The efficacy of soil treatment with nematicides and bio-nematicides to control root-knot nematode (*Meloidogyne incognita*) on tomato crop in unheated polyethylene houses
5. The efficacy of soil treatment with bionematicides and nematicides to control root-knot nematode (*Meloidogyne incognita*) on cucumber crop in unheated polyethylene houses
6. The efficacy of biological treatment of soil to control root-knot nematode (*Meloidogyne incognita*) on pepper crop in unheated polyethylene houses
7. The efficacy of soil treatment with bionematicides to control root-knot nematode (*Meloidogyne incognita*) on cucumber crop in unheated polyethylene houses
8. The efficacy of soil treatment with bionematicides and nematicides to control root-knot nematode (Meloidogyne incognita) on cucumber in heated Israeli-style greenhouses
9. Evaluation of botanicals to control whiteflies (*Trialeurodes vaporariorum*) in tomato crops
10. Effectiveness of reduced-risk pesticides in the control of glasshouse whitefly (*Trialeurodes vaporariorum*) on tomato
11. Integrating fungicide control programs for maximize economic return on tomato production in greenhouses
12. Integrating fungicide control programs for maximize economic return on cucumber production in greenhouses

13. The effect of soil solarization to control of root-knot nematode (*Meloidogyne incognita*) on lettuce (second crop) in unheated plastic greenhouses
14. The effect of solarization with irrigation and without irrigation pre-solarization to control root–knot nematode (*Meloidogyne incognita*) on lettuce (second crop), in unheated polyethylene houses
15. The efficacy of soil solarization with one and two white plastic sheets, to control root-knot nematode (*Meloidogyne incognita*) on lettuce (second crop), in unheated plastic greenhouses
16. The efficacy of combination soil solarization + biofumigation (with poultry manure) to control root-knot nematode *Meloidogyne incognita* on tomato (second crop), in unheated polyethylene house
17. The efficacy of soil treatment with nematocides, bio-nematicides to control of root-knot nematode *Meloidogyne incognita* on tomato (second crop) in heated Israeli-style greenhouses
18. The efficacy of soil solarization to control root-knot nematode *Meloidogyne incognita* on tomato (second crop)
19. The efficacy of soil solarization to control root-knot nematode *Meloidogyne incognita* on cucumber (second crop)
20. Evaluation of fungicides for botrytis control of greenhouse tomato
21. Evaluation of miticides to control two-spotted spider mites (*Tetranychus urticae*) in cucumber greenhouses
22. Effectiveness of several insecticides and natural compounds for aphid control on greenhouse tomatoes
23. Soil solarization and grafting as alternative for pests and diseases control in greenhouse tomato production system
24. The efficacy of different nematicides in controlling of root-knot nematodes (*Meloidogyne* spp*)* on tomato and cucumber grown in heated Israeli-style greenhouses
25. Soil solarization, a non-chemical method to control root-knot nematodes (*Meloidogyne* spp*)* on spinach in northern Albanian-style greenhouses
26. The efficacy of soil solarization and different nematicides used to control root-knot nematode (*Meloidogyne incognita*) on cucumber in unheated plastic greenhouses in northern Albania
27. Effect of BioNem, Nemafung and Softguard on control of root-knot nematodes (*Meloidogyne* spp*)* on cucumber grown in unheated plastic greenhouses in northern Albania

Number of new technologies or management practices being field tested as a result of USG assistance

Soil solarization

1. Grafting
2. Pests and diseases monitoring
3. Bio-nematicides

   Number of additional hectares under improved technologies or management practices as a result of USG assistance.

4. 20 ha of greenhouses that are doing soil solarization.

   Number of rural households benefiting directly from USG interventions.

   Number of producers organizations, water users associations, trade and business associations, and community-based organizations (CBOs) receiving USG assistance.

5. Agriculture Farmer’s Association Kemishtaj Lushnje
6. Farmer’s Association Kosmac Shkoder
7. Year 2007 - 104 individuals (75 man and 29 women)
8. Year 2008 - 305 individuals (216 man and 89 women)
9. Year 2009 - 140 individuals (93 man and 47 women)

Total: 549 individuals (384 man and 165 women)

Number of individuals who have received USG supported long-term agricultural sector productivity training (disaggregated by sex).

***Tuta absoluta* monitoring**
After our return from Greece we have start the monitoring of *Tuta absoluta* in different region of Albania (Shkoder, Tirane, Fier and Vlora). After our observations we have found the pest in tomato (greenhouse Novosela - Vlora region) and in open field (Levan Fieri). We have informed the Ministry of Agriculture about this new pest. With our colleagues we have prepared an article “*Tuta absoluta* nje kercenim per kulturen e domate” that we be published in the next month in “BUJQESIA” journal and a leaflet is produced for the farmers of tomato cultivation in open fields and in greenhouses.

Moldova

Institute of Plant Protection and Ecological Agriculture – PROBIO
Vladimir Todirash and Douglas Pfeiffer

Phenological studies and temperature/precipitations-based models: Influence of temperature and precipitation on *Alternaria* in tomato fields was studied for elaboration of a forecast model. It was found a strong correlation between disease incidence, temperature and precipitations.

The interactions among microclimate components on powdery mildew on cucumbers and *Alternaria* on tomatoes using SPS and GIS technologies was studied. Information from disease models can be used to simulate and predict the intensity and potential threat. Simulation models, GIS and interpolation techniques were integrated in a computer system. The system outputs represent information by which the decision making activity can be improved. It was shown that the integration of phenological models in GIS allows producing complete information for decision making. The phenological model for *Helicoverpa armigera* on tomatoes based on accumulation of degree days was tested with scope to improve control decisions. The model needs supplemental field tests in order to be implemented.

Studies of efficacy of rape seed oil derivatives toward arthropods pest and diseases.

The effect of a microemulsion based on rape seed oil derivatives on greenhouse pests was studied. The insecticidal activities of the rape seed oil derivatives were investigated on control of greenhouse whitefly (*Trialeurodes vaporariorum*), twospotted spider mites (*Tetranychus urticae*) and aphids (*Aphis gossypii*). The insecticidal and miticidal microemulsion does not cause phytotoxicity but has satisfactory effects even when used in a lower concentration.

Control of greenhouse pests has been increasingly successful but there is still a need for insecticides where integrated pest management can be difficult to implement. Whitefly has several life stages, including eggs and puparia, which may be resistant to many insecticides, and even the different nymphal stages and the adults can vary in susceptibility to an insecticide. Twospotted spider mites are not insects and can tolerate many chemical insecticides. Moreover, these mites and insect pests, in general, easily acquire tolerance to chemicals and therefore the insecticidal and miticidal effects decrease.

There are several organic controls that work well, as their mode of control differs from that of a chemical insecticide. The fatty acid salt active ingredient is known to be effective against insects and mites. There have been used various compositions for control of arthropod pests such as spider mites, and aphids. Least-toxic pesticides used against aphids in greenhouses include insecticidal soap and horticultural oil. However, these pesticides have no residual activity and thus must contact a target pest to be effective. Despite the known effectiveness of certain fatty acid-based compositions as pesticides, there is still a need for similar environmentally-compatible compositions that provide enhanced efficacy as well as ease and economy of manufacture.

A clear, physicochemically stable, oil-continuous microemulsion was developed, composed of glycerol 10%, ethyl alcohol 15 %, rape seed potassium salt of fatty acids and ethyl esters in the ratio 1:0; 2:8; 5:5 or 5:95 and 4-8% water. All microemulsion ingredients are ecologically safe and correspond to requirements for organic production. For treatments a water-continuous microemulsion comprising as active ingredients a mixture of potassium salt and ethyl esters of ripe seed fatty acids was prepared and diluted with distilled water. Then, one of the following substances was added thereto: sodium carboxymethyl cellulose as a moisture-retaining substance or Silwet L-77 as a surfactant.

It was found that practical control effect can be obtained even if the concentration of fatty acid potassium salt: fatty acid ethyl ester mixture is 0.5%, whereas the concentration of fatty acid potassium salt which produces practical control effect is 1% based on the total weight of the liquid solution when fatty acid potassium salt is used alone.
First instar larvae of the spider mite were used in the tests. Mortality was determined on the 3rd day after the treatment. Larvae were considered to be dead when they did not respond to touch and their color faded. Mite mortality depends on microemulsion concentration. The treatment with 1.5% and 1.0% microemulsions killed 98.5% and 86.4% of larvae, respectively.

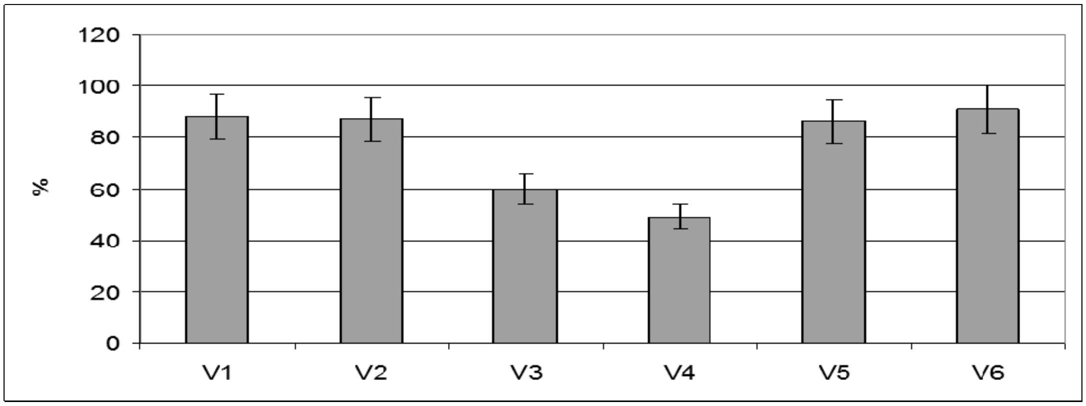


Figure 3: Whitefly imago mortality in dependence of mixing ratio (MR) Fatty acid potassium salt: fatty acid ethyl esters. V1- MR= 0:100; V2- MR=20:80; V3- MR=50:50; V4- MR= 5:95; V5 MR=50:50+ sodium carboxymethyl cellulose 0.1%, V6- MR=50:50+ Silwet L-77, 0.025% Asterisks indicate significant difference at P < 0.05.

It was found that a surfactant, a monovalent metal salt having an action of enhancing surface activity or a moisture-retaining substance, remarkably improves the insecticidal activity of fatty acids. Intrinsic changes that increase spreadability could also increase the ability of compounds to improve efficacy.

In our experiments Silwet L-77, known to be good spreader, in tested concentration did not increase the efficacy of the microemulsion (Figure 2). Analogous results were obtained with sodium carboxymethyl cellulose. Perhaps this is result of presence of glycerol in the composition. It is well known glycerol is hygroscopic and moisture retaining, improving efficacy of pesticides.

The microemulsion whose active ingredient was a mixture of potassium salt of fatty acids and fatty acids ethyl esters exhibited superior effect to that of the control using potassium salt of fatty acids alone (Figure 3). However stability of the microemulsion depends of mixing ratio (MR) potassium salt of fatty acids to fatty acids ethyl esters. When the mixing ratio between the fatty acid esters and the potassium salt of fatty acid is outside the range of 80:20 to 95:5, a microemulsion cannot be formed or the stability of the microemulsion is deteriorated even when it is formed, therefore it is not preferable that the mixing ratio is out of the above-mentioned range.

According to the present results, it is possible to reduce the fatty acid content in a fatty acid insecticide. Moreover, fatty acid ethyl esters can act not only as adjuvant, but as active substance of insecto-acaricidal preparations. Thus, it becomes possible to supply an environmentally safe insecto-acaricidal microemulsion based on rape seed oil derivatives at a low cost.

Field experiments on efficacy of low toxicity preparations in control of arthropod pests and diseases on tomato and cucumber:

Studies were carried out with powdery mildew on cucumbers and *Alternaria* on tomatoes. IPM trials were conducted in tomato field using different concentrations of new liquid copper formulation Funecol. Preliminary tests showed that preparation

Funecol 0.2-0.3%, is effective in reducing the incidence of *Alternaria.*

Mineral oil (summer oil), extract from *Reynoutria sachalinensis* (giant knotweed), and bicarbonate were tested against powdery mildew on cucumbers in greenhouses and open fields. Studies of powdery mildew on cucumber have shown the perspectives of special composition of vegetable oil derivates in the control of this disease. It was found that *Reynoutria* also controlled mildew on cucumber and melon. The best result was obtained after treatment with mixture of *Reynoutria* extract and microemulsion based on rape seed oil derivatives.

In greenhouses, the efficacy of botanical pesticides for greenhouse whitefly, *Trialeurodes vaporariorum,* and twospotted spider mite, *Tetranychus urticae,* were evaluated. Field studies on cucumber and tomato were organized in the Bardar village of Ialoveni district. A new preparation based on Pyrethrum + rape seed oil derivatives against whiteflies in greenhouses has shown promising results.

It was found that yellow traps can be used together with treatments by microemulsion based on rape seed oil derivatives to eradicate the whitefly.

Educational meetings and training on IPM for farmer groups

In cooperation with the Ministry of Agriculture and Food Industry short term courses on integrated pest management were carried out in April, 2009. The materials distributed included the systems for integrated pest management, utilization of *Trichogramma* in plant protection systems, new methods of scouting and monitoring for agricultural pests and Identifications of pests and diseases of vegetable crops and their natural enemies.

1. June 12, 2009
Workshop with experimental fields demonstrations "Ecologically safe methods for protection of vegetables" organized together with Consulting Agency ACSA in Ocnita district. Participants: 19 farmers and specialists.

2. June 22, 2009
Workshop with experimental field demonstrations “Biological means in plant protection"" Ialoveni district, participants: 22 farmers and specialists

3. September 21, 2009
Workshop "Integrated plat protection in greenhouses" with demonstration and training. Participants: 15 farmers and specialists organized together with Consulting Agency ACSA we organized two workshops in Ocnita district, participants: 17 farmers and specialists.

Publications:
The main Project results were presented at: International Conferences “Integrated systems of field crops pest management, Balti 2009 and IOBC WORKING GROUP“ Integrated Control in Protected Crops, Mediterranean Climate” 6-11 September 2009 Chania (Insecto-acaricidal effect of microemulsion based on rape seed oil derivatives V. Todirash , D.G. Pfeiffer, T. Tretiacov, V. Focsa)

The book Integrated Pest Management and Quality Assurance of Stored Products, 2009 (in Romanian), authors V. Todiras, Iu Balan, and T. Tretiacov, was edited and published.

Ukraine

IPM CRSP activities in Ukraine (Lviv, Odessa and Dnipropetrovsk Oblasts)

O. Cholovska, M. Ishchuk, V. Kotsur, M. Kharytonov, K. Maslikova, M. McGiffen and D. Pfeiffer

Workshop on integrated vegetable production

In winter period 2008-2009, materials were prepared and an integrated vegetable production workshop was held on 15 February in the village Pynyany, Sambir district, Lviv region. Farmers were present at the workshop, both those who are involved into the project and local farmers and stakeholders who grow cucumbers and vegetables. At the workshop a representative of the organic farm "Yukhyma", in the village of Sknyliv, Zolochiv district, delivered a presentation, among others, sharing his experience in organic farming. A representative of Bayer company seed department "Numens" made a presentation, explaining to farmers and stakeholders the demands of growing different varieties of cucumbers and other vegetables.

Introduction of an integrated system of cucumber production

In order to introduce an integrated system of cucumbers growing in Lviv oblast, tests were set up in fields located in the following farms and institutions: Farm "Rever" v. Otynevychi Zhydachiv district; Farm "Zorya" village Zorotovychi Sambir district; Private enterprise of Pitylo Oleh in the village Pynyany Sambir district; Private enterprise of Radukh Lyuba in the village Artasiv Zhovkva in the village Pidhirne Pustomyty district Lviv region; Western scientific research center of agro-technical systems engineering in the village Pidhirne Pustomyty district Lviv region. All participants of the project were given seeds of cucumbers from the Dutch company "Numens" (varieties "Ayaks", "Hector", "Sparta") as well as schemes of integrated system of cucumber growing.

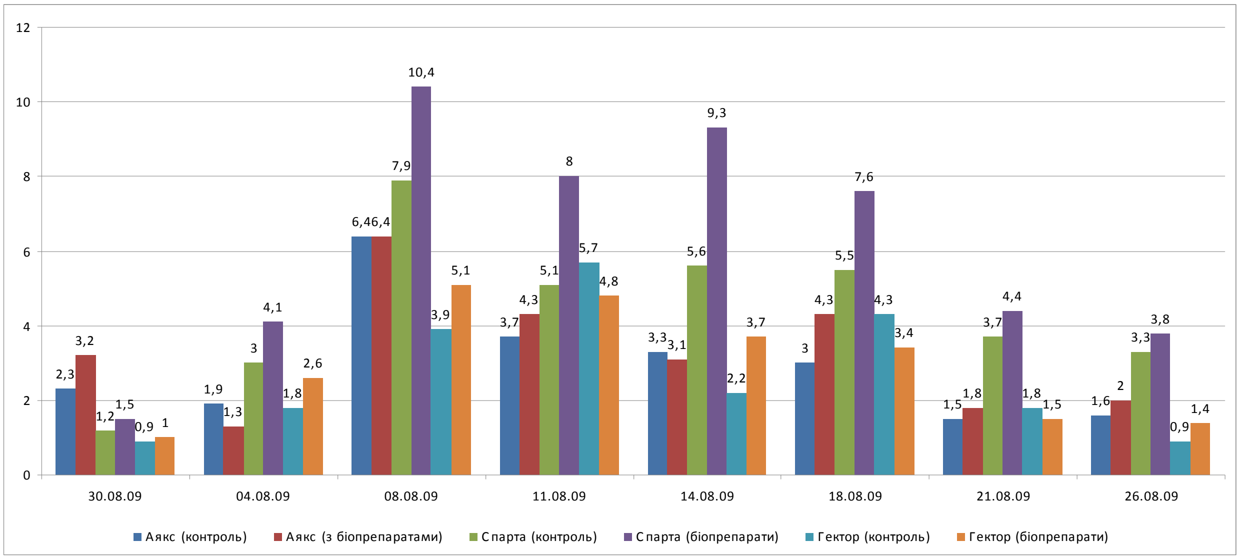
Planting was carried out from 20-25 May. Before planting, farmers applied 0,5 tons of complex nitrogen N16, P16, K16 per hectare; in addition, in autumn the farm "Zorya" applied barnyard manure at the rate of 20 t/ha. Fertilizer "Vuksal" was applied as side-dressing at the rate of 1 l/ha at the farm "Rever". In autumn 2008, at the private farm of Pitylo Oleh 20 t/ha of barnyard manure was applied to cucumber fields. Fungicides were not sprayed. Planting of seedlings of cucumbers was done in March. Cucumbers grew under plastic. Harvesting was started in the second half of May. On the farm of Radukh Lyuba 200 kg/ha of complex fertilizer N16, P16, K16 was applied before planting. During the growth period, Rydomil Gold MC 68 WG (metaxyl+manko cep) at the rate 2 kg/ha was applied to cucumbers. In 2009, in the Western Scientific Research Center of Engineering of Agro-technological Systems the work was continued on organic cucumber production with the use of soil agro-bacteria during planting. On test fields, soybean preceded cucumbers in rotation. In spring, fields were plowed - two cultivations and leveling of the soil. Mineral fertilizers were not applied, but biological agents "Flavobacterin" and "Agrofil" were used. Planting of the test field was performed on the 20 May. The test was set up in three replications. In each replication all three varieties of cucumber (Sparta, Ayaks and Hector) were planted on the plot using hand seeding machine with special equipment for introduction of bacterial agents at planting. Every variety in each replication was seeded simultaneously with biological agent and another plot was a control without biological agents. Width of test field was 25 meters, length -10 meters. In the first decade of July, Actara 240 SC (thiamethoxam) at the rate of 6 g/5 l was sprayed to control aphids. At the same time, the fungicide Infinito 61SC (fluopicolit + propamocarp hydrochloride) 687,5 CM at the rate of 15 ml/5 l using 5 liters of working liquid per 1 sq meter was applied. Herbicides were not applied but there were two hand weedings. Harvesting of cucumbers on test fields began on the 30 of July and was over by the end of August.

Yields depended on varieties and applied biological agents. The highest yield demonstrated variety Sparta. In connection with the problem of possible late spring frosts in our region planting of cucumbers was done in the 3rd week of May. Two years data show that the variety Sparta gives better yield than Ayaks and Hector with late terms of planting. The greatest response to biological agents applied to the soil variety was shown by the variety Sparta (Table 3, Figure 4). The longest term of yielding was marked at the variant with variety Sparta.

Table 3: Yields of Ayaks, Sparta and Hector, with and without soil-applied biological treatments

Name of variety		Yield from 1 linear meter (in kg)	Yield from 1 ha (in c)	Increment of yield (+ −) (c)
Ayaks	control	2,3	23	
	Application during planting of flavobacterin and agrofil	2,6	26	+3
Sparta	control	3,8	38	
	Application during planting of flavobacterin and agrofil	4,9	49	+11
Hector	control	2,1	21	
	Application during planting of flavobacterin and agrofil	2,4	24	+3

Figure 4: Yields of cucumbers at test field according to the dates of harvesting in kg.



__Ayaks (control)	__ Ayaks (with biological agents)	__Sparta (control)	__ Sparta (with biological agents)	__Hector (control)	__Hector (with biological agents)

Taking into consideration the results obtained, it is possible to recommend to stakeholders and farmers who would like to conduct organic farming to apply bacterial agents of natural origin instead of expensive nitrogen fertilizers. Comparison of the prices is as following: ammonia saltpeter costs 250 hryvnyas per hectare while a complex of biological agents costs 25 hryvnyas per hectare). Another advantage is that the production with biological agents is ecologically clean, it especially pertains to vegetable production as vegetables are consumed fresh.

Study on alkalinization of orchard using cereals and legume crops

In April 2009 the experiment on alkalinization of apple orchard in the farm “Anastasiya” was set up. For the experiment such grasses were used: timothy, white clover and lawn grass. There were four replications of 10 meters each. On 11 August 2009, samples of ground cover plants were taken from each replication in 4 subsamples in chess order. It was taken and analyzed 12 samples altogether. Weeds were identified, and weight of all plants was determined according to type, both tested grasses and weeds (Table 4).

Table 4: Average weight of plants from three variants:

Name of the weed	Variant №1 (Timothy)		Variant №2 (White clover)		Variant №3 (Lawn grass)	
	Number of plants per м²	Weight in grams	Number of plants per м²	Weight in grams	Number of plants per м²	Weight in grams
Foxtail (*Setaria glauca*)	43	420,0	27	250,0	64	360
Dandelion (*Taraxacum officinale*)	5	3,4			7	14,0
Horsetail(*Equisetum maximum*)	22	46,6	19	28,6	70	210
Thistle (*Cirsium arvense*)	11	105,0				
Sorrel (*Rumex obtusifolius*)	5	14,8	6	60,2		
Amaranth (*Amarantus retroflexus*)			21	170,0		
Agropyron (*Agropyren repens*)	4	7,4	14	10,6	2	3,7
Galinsoga(*Galinsoga parviflora*)			1	2,9		
Russian knapweed(*Poligonum aviculare*)	11	23,8				
Knapweed (*Poligonum convolvulus*)	2	3,0			2	3,2
Knapweed (*Poligonum persicaria*)	5	12,8	1	4,5		
Campion (*Silene noctiflora*)	3	4,6	3	15,3		
Milfoil (*Acyillta millefolium*)	10	13,7	3	4,6	5	3,3
Orach (*Chenopodium album*)	3	5,3				
Winter vetch (*Vicia hirsuta*)			1	0,7	2	3,4
Average weight of main crops:		900		2870		1000

Correlation of weeds (in %) to the main crop for different tested grasses is the following: 74 % in timothy, 19 % in white clover, 41 % in lawn grass. The most widespread weeds in all three grasses are foxtail (*Setaria glauca*) and horsetail (*Equisetum maximum*). Experiment has just started that is why yields and quality of production data are not available at the moment. After taking samples the grass in the orchard was cut.

Organization of two seminars on the basis of integrated growth of strawberry and vegetables on the basis of the farm "Pan Bilan" Bilyayiv district, Odessa region

In September 2009, two seminars were held: on integrated system of strawberry and vegetable production on the farm "Pan Bilan" of Bilyayiv district Odessa Region. There were 30 and 35 farmers at the two workshops, respectively. Demonstrative fields of three varieties of strawberry (Honey, Clary and Marmelada) with different systems of growing and protection were presented. Demonstrative plantations of vegetables (tomatoes, cabbage and pepper) were presented at the second workshop. Olena Cholovska presented at both workshops, sharing the experience of Lviv tests, demonstrating the book on apple orchard, published by the project in 2008, and delivering the information obtained during her visit to the symposium in Portland and meeting in Chania, Greece. At the latter the integrated systems of tomato growing were demonstrated and at both meetings a lot of urgent problems of integrated growing of vegetables were discussed. At the plenary meetings in Odessa region scientists and farmers discussed questions of integrated growing of vegetables in Ukraine.

Participation in international conferences

Olena Cholovska and Myroslava Ishchuk participated in the 6th international IPM symposium in Portland OR, USA, they were co-authors of the poster: "Multilingual on-line presentations for the dissemination of IPM research results to an international audience. In addition, they attended the meeting "Integrated Control in Protected Crops, Mediterranean Climate" sponsored by the International Organization for Biological Control, in Chania, Crete, Greece. The information obtained will be disseminated at future workshops between farmers of our country and used in practical work on the fields.

Application of integrated system on fields of strawberry and on vegetables on the farm "Pan Bilan" in Bilyayev District Odessa Region

During the period of vegetation in 2009 on the farm "Pan Bilan" integrated system of vegetables and strawberry from diseases and insects was applied, it combined action of biological agents and chemicals in order to minimize contamination of agricultural products. Among the most widespread insects on Solanaceae crops (tomatoes, pepper, eggplants) in Odessa region are Colorado potato beetle, different types of cutworms, aphids, cicada (locust), wireworms. On cabbage – cabbage whitefly, cabbage moth, cutworms, aphids, thrips. The most damaging diseases in this zone are: phytophthora (usual and southern), macrospore, septospora, and bacterial spot. Pepper and eggplants in the recent years have been seriously damaged by root rots, fusarium and verticillosis, causative agents if which are accumulated in the soil and preserved there for long years. Very damaging to solanaceae crops are virus and micoplasma diseases (stalbur, tomato stric, yellow [fairies'-horse, kettle-doc]) which make fruits absolutely unsuitable for consuming. These diseases are spread by insect -transmitters: aphids, cicadas, thrips, mites. On strawberries the most damaging are strawberry mites, weevils-flower-eaters, caterpillars of leaf-rollers, wireworms, mice. Ripe fruits are often damaged by ants. The most damaging diseases on strawberry are root rots, white and brown spot of leaves, grey rot of fruits. Mildew and phytophthora of strawberry have not been noticed by now in Odessa region. Integrated system included protection of seedlings of our own production, which were grown in greenhouses in cassettes and insects control in fields during their growth and fruiting.

During the growth of seedlings of vegetable crops, the protection system included:

1. Disinfection of cassettes by 3 percent solution of manganese crystals, by wetting them in the solution
2. Using only high quality treated seeds of famous companies production
3. Watering of shoots by 1,5 % solution of fungicide Previcur 607CL, water solution (2-4 liters of 0,15 % solution per1 sq. meter) to control black leg, peronospora and root rots
4. Treating of seedling by growth stimulator on humic basis-potassium humate, powder (0,1 % solution) and out of root feeding of plants by microelements (water soluble combined fertilizer of the series of Master)
5. Treating of seedlings before planting into the soil by mixture of insecticide and fungicide of systemic mode of action to protect against complex of diseases and insects (Confidor Maxi, water-soluble granules (0,05 kg/ha)+Rydomil Gold, water-soluble granules (2,5 kg/t of water)
6. Two weeks before planting the field was sprayed with herbicide of entire action

on the basis of glyphoshate-Roundup Bio, water solution (6 l/ha) to control all types of weeds

7. After planting of seedlings into the field, nutrients (microfertilizer Master) and biological agents to control root rots (Thrykhodermin) and to control soil insects and diseases (Gaupsin), were applied along dropping tube simultaneously with watering, 5 l/ha of each. Biological agents and fertilizers were applied each 10 days (altogether there were 10 applications)
8. To control Colorado potato beetle and sucking insects (aphid, thrips, цикадка) neonicotinoid Konfidor Maxi was applied, water soluble granulas (0,05 kg/ha) (2 applications in 20 days)
9. To control caterpillars of cutworms, tomatoes and eggplants were sprayed twice with insecticide of hormonal action Match 050EC, E (0,4 kg/ha).
10. To prevent bacterial spot and other diseases of tomatoes copper oxychloride, (3 l/ha) was applied. Two treatments of plants were conducted: the first in 2 weeks after planting into the fields, the second–on young green fruits.
11. To control phytophthora, macrospora, alternaria and other spots of leaves fungicide Quadris (Quadris) (0,8 l/ha) at the phase of budding and on green fruits was applied twice.

The following system of protection was used on early cabbage:

1. The protection of cabbage seedlings in greenhouses was analogical to the protection of solanaceae crops.
2. After planting of seedlings into the soil, they were regularly fed by water soluble complex fertilizers of Master series.
3. To control caterpillars of whitefly, cutworms and moths 2 treatments of plants by insecticide of hormonal action Match (1 kg/ha) with the interval of 30 days between treatments were done, to control sucking insects (aphid, thrips) Confidor Maxi, water soluble granules (0,05 kg/ha), with the interval of 20days was applied.
4. During the period of early cabbage development it was dry hot weather which did not encourage diseases development that is why no fungicides were applied. To prevent root rots at the beginning of vegetation period, solution of biological agent Trichoderma at the rate of 7 l/ha was provided through dropping tube.

System of strawberry protection included the following measures:

1. Seedlings of strawberry were grown in special cassettes on our farm during the summer period of 2008. To propagate strawberry the first rosette of elite plant tendrils of strawberry was taken. The elite strawberry was brought previous year from the nursery “Vivay Macconi”, Italy.
2. Before planting, rosettes were wetted in the solution of fungicide Quadris, (0,8 l/t of water), and then each seedling was dropped into the powder of stimulator Kornevin, watering powder (2g/100 seedlings) to encourage quick development of root system.
3. During the period of seedlings growth they were treated by stimulator of growth Gumat of potassium, powder (0,1 kg/ha) and fed out of roots by complex water soluble fertilizers with microelements (Master group). After 30 days in cassettes seedling are ready to be planted into the field. Planting of the commercial plantation of strawberry was carried out in the first decade of August 2008. Planting was done into furrows covers by black plastic. Planting was done in two rows, density 55000 plants /ha. Area under strawberry – 3 ha. The

varieties planted were: early varieties – Klary and Honey, mid-early varieties – Marmalade and Antea.

4. After planting into the field strawberry plants were only fed by micro fertilizers simultaneously with watering. There were no diseases nor insects.
5. In spring, April 2009, before mass flowering of strawberry prophylactic treatment with insecticide Confidor Maxi, water soluble granules (0,05 kg/ha) in tank solution with stimulator of growth Lignogumate, powder (0,01% water solution) was applied.
6. To protect fruits from grey rot, green fruits of strawberry were sprayed with fungicide Teldor 50, water soluble granules (0,8 kg/ha).
7. Biological agents Trichoderma and Gaupsin (5 liters of each) with the interval of 10 days were applied with the help of a dripping tube to prevent root rots.
8. During harvesting of fruits no treatments were conducted. After harvesting, the plantation was sprayed twice with biological agent Acrofit, 0,2% concentrate mixture (2 l/ha) to control mites and sucking insects.
9. To control spot of leaves and to prevent root rots fungicide of systemic action Derozal, concentrate mixtures, 0,5 l/ha was applied (two treatments if necessary) only after harvesting.

Dnipropetrovsk

Two training courses on IPM for tomatoes and cucumbers were conducted.
The first group included owners of dachas who live in the Dnipropetrovsk District (30 persons attended). The second group included owners of dachas who live in Pavlograd District, where they use reclaimed lands to grow vegetables and orchards (32 persons attended). DSAU was responsible for conducting the scientific conference: Plant and Human Relations; both Mykola Kharytonov and Kateryna Maslikova took part. A joint oral paper untitled "Prospects for IPM dissemination in Ukraine" was written and presented by Kateryna Maslikova, Mykola Kharytonov and Doug Pfeiffer.

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

Wondi Mersie, Virginia State University

Distribution of Parthenium in Eastern Africa

Surveys were conducted in North West Ethiopia bordering the Sudan, North East Ethiopia bordering Djibouti, and some parts of South West Ethiopia. The survey data will be included in the parthenium distribution data base maintained in South Africa by PPRC.

Parthenium was sighted in Uganda in 2008 for the first time. The weed has been rapidly multiplying in several spots across Uganda, especially along the highway from Busia (Kenya-Uganda border) to Kabale. Currently, it has been detected in at least 12 districts (Busia, Namutumba, Bugiri, Mbale, Jinja, Mbarara, Ibanda, Masaka, Kampala, Kabale, Kasese). There is a need for an extensive survey to establish more accurately the extent of parthenium distribution and spread in Uganda. The IPM CRSP parthenium project partners have been conducting monitoring activities after the initial mechanical control efforts in December 2008 at Namalemba and Bugembe sites.

The effect of parthenium on plant diversity

A soil seed bank study was conducted to quantify the amount of parthenium seed in the infested soils of the Tigray region. Samples from disturbed and undisturbed soil were collected using a soil auger to a depth of 10 cm. The number of seeds in the soil samples was determined by putting the soil in plastic pots in the greenhouse and letting the weeds germinate. Germinating seedlings of parthenium and other weeds were counted and were removed at intervals of two weeks.

Results showed that some fields of the surveyed area were infested with up to 181 viable parthenium seeds per 190 cm^3 of soil taken from the upper 10 cm depth. Infestations of parthenium are also observed to be wide spread in both pasture and crop lands.

Biological control of parthenium weed

Progress of work at Ambo Research Center

In Ethiopia, the control of parthenium weed in crop fields is mostly done with manual labor which is not effective, time consuming, expensive at times and inapplicable in pasture lands. On the other hand, the use of insects (natural enemies) for the control of weeds is nonexistent. The IPM CRSP parthenium project is a pioneer in weed biological control in Ethiopia. Looking for alternative control strategies against parthenium weed, the leaf-feeding beetle, *Zygogramma bicolorata* (Coleoptera: Chrysomelidae) was introduced from South Africa into Ethiopia in October 2007, after establishing standard quarantine rooms equipped with the necessary materials. The main objectives were to maintain and multiply the introduced bio-agent (*Z. bicolorata*); to evaluate the beetle extensively in enclosed quarantine conditions to determine the potential host plants in Ethiopia; and eventually release and monitor the insect in selected parthenium infested sites.

The quarantine facility

Establishment of a quarantine facility was a prerequisite for import of the insect. The 46 sq m facility was inspected and approved as meeting international standards. The quarantine facility has rearing and testing rooms. Within the rooms there are walk-in-cages and rearing cages. The rooms are air-conditioned to maintain a daily temperature range of 20-30°C and a relative humidity of 50-88%.

Zygogramma bicolorata

A starter colony of 300 larvae and 531 adults of bio-agent (*Z. biocolorata*) were introduced from ARC-PPRI, for bio-control and host-specificity studies. It has established well on parthenium under quarantine conditions and completed more than 25 generations.

For host range testing crop and non-crop plants were selected by a systematic botanist from Addis Ababa University. The selection was based on the closeness of the species to parthenium weed. In addition, economically important crops not related to parthenium were also included in the test as a precautionary measure. The plants were first grown in a nursery and then transferred to the testing facility. For testing purposes young, healthy test plants of similar size were selected, washed, and checked for other insect pests and/or natural enemies. All test plants were allowed to adapt to the quarantine conditions for at least 24 hours before initiating the trial. All tests were replicated three times.

No-choice tests were designed to determine whether the *Z. bicolorata* beetle will feed, lay eggs and/or survive on a test plant when when it cannot access the target weed parthenium. Ten healthy reproducing pairs (10 female + 10 males) of adult *Z. bicolorata* were released per potted plant. The plants were regularly watered and the leaves sprayed with 2% bleach solution daily. After 10 days of exposure all adults were removed from each test plant and put in a freezer.

In choice trials, insects were caged with test plants and the host plant (parthenium). The test plants were considered if they showed positive results (feeding and/or oviposition) under no-choice trials. This was designed to test whether the bio-agent preferred to feed, lay eggs, and develop on a test plant in the presence of parthenium or it avoided the test plant in preference to parthenium weed. The same methodologies were followed as no-choice tests, except that each cage contained a control plant parthenium and a test plant.

After 10 days the adults were removed from the trial and the number of adults that survived, died, and/or were missing was recorded. The number of eggs or larvae present on the plant was counted. The extent of feeding was assessed by determining the percentage of the total number of leaves that exhibited feeding symptoms. The range of feeding damage was categorized by a scale of 0-5 (0 = 0%, 1<10%, 2<20%, 3≤40%, 4≤60% and 5 >60% leaves with feeding symptoms).

The results of host range testing under the no-choice condition showed that *Z. bicolorata* is safe for crop and non-crop plants closely related to parthenium (Table 1). Out of seven parthenium related weed species tested, only *Bidens sp.* had shown feeding symptoms (<10%**)** produced by *Z. bicolorata*.

Table 1: *Zygogramma bicolorata* adult feeding, oviposition and larvae development in no-choice tests at Ambo Plant Protection Research Center, Ethiopia

Species/variety	Common name	Feeding*	Oviposition	Larvae developed	Larvae pupated
Guizotia abyssinica (Local)	Niger seed	2	+	0	0
G. abyssinica (Fogera)	Niger seed	0	0	0	0
G. abyssinica (ESTE)	Niger seed	1	+	0	0
G. abyssinica (Kuyu)	Niger seed	1	+	0	0
G. abyssinica (Shambu)	Niger seed	1	+	0	0
Guizotia scabra	Mech	0	0	0	0
Carthamus tinctorius	Safflower	0	0	0	0
Helianthus annuus (Local)	Sunflower	2	+	+	0
Helianthus annuus (Lisa)	Sunflower	3	+	+	0
Helianthus annuus (R.B)	Sunflower	2	+	+	0
Bidens pilosa		0	0	0	0
Bidens ghedoensis		0	0	0	0
Bidens pachyloma		0	0	0	0
Bidens sp.		1	0	0	0
Flaveria trinervia		0	+	+	0
Galinsoga parviflora		0	0	0	0
Conyza bonariensis		0	+	+	0
Tagetes minuta		0	+	+	0
Lactuca sativa		0	+	+	0
Vernonia galamensis		0	+	+	0
Parthenium hysterophorus	Parthenium	5	+	+	+

**(0 =0%, 1<10%, 2 <20%, 3 ≤40%, 4 ≤60% and 5 > 60% leaves with feeding symptoms)*.

As a precautionary measure, the following economically important plants which are not closely related to parthenium were also tested under no-choice condition: faba bean, pepper, maize, tomato, haricot bean, lentil, potato, wheat, chick pea, field pea, teff, sesame, rough pea, and cabbage. There was no feeding at all on any of these crops.

Table 2: Range of feeding of *Z. bicolorata* adults on test plant species in choice test

Test plant species	Mean total number of leaves/pot	Mean total leaves with feeding symptoms	Range of feeding *(0-5 scale)
G. abyssinica	135	0	0
Sunflower -Oissa	98	24	3
Sunflower –R-black	92	29	2
Bidense aspilia	231	0	0
P. hysterphorus	141	107	5

**(0 =0%, 1<10%, 2 <20%, 3 ≤40%, 4 ≤60% and 5 > 60% leaves with feeding symptoms*).

Test plants that showed feeding symptoms under the no-choice condition, (niger seed, sunflower varieties, and *Bidens aspilia*) were retested along with parthenium (Table 1). It was confirmed through repeated choice experiments that regardless of slight feeding symptoms and larvae development in some cases, the bio-agent could not complete its life cycle. Though oviposition was recorded on the stem and leaves of some of the test plants, the eggs either dried out before hatching or the larvae could not survie more than 24 hrs (Table 2).

Table 3: Number of eggs and larvae recorded after 10 days of choice testing on selected test crops

No.	Test plant included under choice test	Total Number of larvae or eggs in 10 days of testing	
		Eggs	Larvae
1	Sunflower- Oissa	2	0
2	Sunflower –R-black	4	0
3	Parthenium (Control)	332	20

The stem boring weevil *Listronotus setosipennis*
An additional glass house has been up-graded to a quarantine facility to be used for testing *Z. bicolorata* as well as a second bio-agent, the stem boring weevil, *Listronotus setosipennis* (Coleoptera: Curculionidae). The facility has an area of 73 sq m. Five hundred adults of the stem boring weevil were imported on 15 September 2009 from South Africa. The agent is being reared in the new facility at Ambo. A similar procedure will be followed to test *L. setosipennis* against crop and non-crop plants.

Release permit for *Zygogramma*
Having assembled all support documents and test data, EIAR applied for a permit to release *Z. bicolorata*. After reviewing the data, the Ethiopian Ministry of Agriculture and Rural Development granted a permit to release *Z. bicolorata*. One suggested site is in the Rift Valley near Willinchiti where there is a high level of parthenium infestation. The release process involves the establishment of a mass rearing site as well as the formation of a committee comprised of farmers, development agents, EIAR researchers, and personnel from the federal and regional Agricultural departments. Based on the Willinchiti experience, additional release sites will be considered.

Progress of work at ARC-PPRI in South Africa

Evaluation of biocontrol agents (for safety of introduction)
The agents that have been selected for South African conditions are the stem-boring weevil *L. setosipennis,* leaf-feeding beetle *Z. bicolorata*, both of which are currently being investigated. *Listronotus setosipennis* is considered suitable for seasonally dry regions such as those that occur in South Africa. *Zygogramma bicolorata* has been shown to be highly effective in Australia.

Listronotus setosipennis, originating from Argentina, is a nocturnal weevil that feeds and deposits frass-covered eggs in flowers and stems. Larvae tunnel into the stems and move toward 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 feeds on leaves and flowers and was imported from Australia, but it was originally collected in Mexico. 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.

Host range testing of biocontrol agents
Host range tests were conducted for *L. setosipennis* and *Z. bicolorata*. Plant species and varieties that are unique and relevant to South Africa were tested.

Listronotus setosipennis
In no-choice oviposition tests 18 non-target species and 13 varieties of sunflower (*Helianthus annuus*) were tested. In these tests, 5 pairs of *L. setosipennis* adults, at least 2 weeks old, were used per test or control plant, with 3 replicates conducted per test plant species. Adults were exposed to a control or test plant for 5 days, after which they were removed. The leaves, stems and flowers of each plant were examined closely for eggs (using a microscope), and any eggs counted. No statistical analyses are shown at this stage as testing is ongoing.

In no-choice larval development tests, 10 adults were exposed to each control or test plant for 10 days (replicated 3 times per test plant species). Thereafter, adults were removed and plants were held for a minimum of 3 weeks. Plants were dissected, and the soil was sifted through to count the number of larvae, pupae or adult progeny.

In no-choice oviposition tests, a few eggs were laid on most sunflower varieties tested, but substantially fewer than on parthenium control plants, and in several instances, eggs were deposited on only one of three replicates of a sunflower variety. Oviposition on sunflower was anticipated due to evidence from laboratory testing in Australia, although there is no damage to sunflower crops by *L. setosipennis* in its native or introduced range. There was no oviposition on the other species that were tested except a few eggs deposited in one replicate each on *Aspilia natalensis*, *Adenostemma caffrum* and *Mikania scandens*.

Twenty test plant species, including 6 varieties of sunflower, have been tested in a no-choice larval development tests, and no *L. setosipennis* progeny have developed on any non-target species, with the exception of *B. gayana* which had a single immature larva.

Further progeny development and oviposition no-choice tests are still to be completed on selected closely related native and economically important species. Choice tests will then be used this coming summer to resolve results for test plant species on which eggs were laid or that could support larval development in no-choice tests.

Zygogramma bicolorata

In no-choice tests, 10 reproducing pairs of *Z. bicolorata* adults were exposed to each control or test plant for 10 days. Three replicates were conducted per test plant species. Adults were removed and plants inspected for feeding and oviposition. Feeding was quantified by counting the number of leaves per plant, number of leaves that had been fed on, and the range (5-100%) of feeding per plant. The total number of eggs and larvae per plant was also counted.

Species that were fed on or received eggs during no-choice tests were tested in multiple-choice tests. In multiple-choice tests, 30 reproducing pairs of *Z. bicolorata* adults were exposed to a control and four test plant species (three replicates of each control and test plant species) within a walk-in-cage for 15 days. Every five days the position of adults was recorded, and plants were rotated so that each of the three rows of plants was closest to the north position once in the trial. Adults were removed and plants inspected for feeding and oviposition. Feeding was quantified by counting the number of leaves per plant, number of leaves that had been fed on, and the range (5-100%) of feeding per plant. Total number of eggs and larvae per plant was also counted.

Z. bicolorata has been tested in no-choice tests on 47 indigenous, exotic and economically important species (including 12 varieties of sunflowers) that are closely related to parthenium in South Africa. Feeding was recorded on 13 of these species and oviposition on 14. In all cases, the relative amounts of feeding/oviposition were significantly less than that recorded on *P. hysterophorus*. All sunflower varieties that were tested in no-choice tests showed signs of predation, and some contained oviposition sights with eggs. All of these species were included in multiple-choice trials to further examine the host range of *Z. bicolorata*.

Multiple-choice tests resolved questions from no-choice tests results with the exception of feeding sites found on two varieties of sunflower, and oviposition on *S. mauritiana*, *A. natalensis*, *C. macrocephalum* and six varieties of sunflower. However, far fewer eggs were deposited on test plants than on the control plants. Larval development trials have been initiated for further investigation. Approximately five more plant species will be tested in multiple choice tests.

In larval development trials, 20 one-day-old eggs were placed onto each test or control plant. After 21 days, all stages of all larvae found were assessed, and any feeding damage was evaluated. The experiment was replicated three times. Two species have been tested so far with larval feeding and development occurring on parthenium only.

It is anticipated that testing will be completed and the applications (to the Department of Agriculture, Forestry and Fisheries, and to the Department of Water and Environmental Affairs) for permission to release *Z. bicolorata* in South Africa will be submitted before the end of 2009.

The thermal physiology of *Z. bicolorata* has been determined and predictive modelling conducted to determine the most climatically suitable areas for releases in South Africa and Ethiopia. These results were overlaid on the distribution map for parthenium. The most suitable areas will be prioritized for releas once permission has been obtained from relevant government authorities.

Pasture management methods for the control of parthenium

The objective of this experiment is to evaluate certain forage grass and legume species which out-compete the weed *P. hysterophorus* in pasture and grazing lands of Ethiopia.

The study was conducted at two locations, Alamata district in the Tigray region in the north, and Jijiga rangeland in the Somali region. Mekelle University in the north and Haramaya University in the east executed the study. At both locations, a split plot design was used with treatments mowing and burning as main plots. Six forage crops, namely *Cenchrus ciliaris, Panicum coloratum, Sorghum sudanese, Vicia dasycarpa, Clitoria ternata*, and *Stylosanthes hamata* were used in sub-plots. The forage species were oversown on burned and mowed strips in four replications. The species were selected based on their adaptability to the local environment, rapid growth rate, and forage values. Botanical counts were taken using a quadrant 1m x 1m before and after over sowing of forage plants. The abundance and frequency of parthenium and other major weeds commonly grown in the area were recorded. The stand count and dry weight of both the six fodder crops and parthenium weed samples in each main plot and subplot treatments were also taken using a 1m by 1m quadrate.

Alamata trial

The oversown forage species both on mowed and burned plots were established. Burning or mowing did not have a significant effect on the establishment of the forage species. The grasses, *Cenchrus ciliaris, Panicum coloratum* and *Sorghum sudanese* established more rapidly than the legumes. Establishment of the vetch (*Vicia dasycarpa*) was rather poor. Averaged over main plot treatments, the mean dry weight of *Cenchrus ciliaris, Panicum coloratum* and *Sorghum sudanese* were significantly ($P<0.05$) higher than the mean dry weight of *Vicia dasycarpa, Clitoria ternate* and

Stylosanthes hamata. The fodder grass *Cenchrus ciliaris* produced higher biomass than *Panicum coloratum* and *Sorghum sudanese.*

Forage species and parthenium stand count

The analysis of variance showed there was no significant (P<0.05) difference between burning and mowing on the parthenium stand count 100 days after planting. Likewise, there was no interaction effect between main plot and sub-plot treatments for stand count. However, there was a significant (P<0.05) difference among forage species for stand count. The highest stand count per m^2 was recorded for *Panicum coloratum* followed by *Cenchrus ciliaris,* and *Sorghum sudanese.* The highest parthenium stand count was recorded on plots planted with *Stylosanthes* (475.67 plants/m^2) and *Vicia* (95.33 plants/m^2), and the lowest on plots planted with Clitoria (Table 4).

A linear correlation analysis showed that forage stand count was negatively correlated (r = -0.773) with parthenium stand count.

In conclusion, the fast growing grasses are more effective in competing with parthenium than slow growing legumes. Burning and mowing have similar effects on forage establishment and parthenium stand count. Since this is a one year trial, the experiment should be repeated to draw sound conclusions and recommendations.

Table 4: Mean stand count of forage species and Parthenium (plants/m^2)

	Cultural practices			
	Mowing		Burning	
	Forage	Parthenium	Forage	Parthenium
Forage species				
Cenchrus	43.04	79.67	21.67	20.67
Panicum	58	46.67	45	8.33
Sorghum	18	26.33	26	28.0
Vicia	0.0	95.33	0.0	100.33
Clitoria	19	10.67	13.67	4
Stylosanthes	24	15.33	15.33	475.67

	Cultural practice	Forage species	Cultural x forage
SE	22.73	44.41	62.44
LSD (5%)	24.43	11.81	20.35

International Plant Diagnostic Network (IPDN) Regional Diagnostics Laboratories

Sally Miller, Ohio State University

Strengthening ties within regional hub and spoke laboratories

Central America: A regional IPDN system with Agroexpertos as the Hub lab has been consolidated during Year 4 with all key players (Universities, Government, private labs) involved in plant disease diagnostics willing to be active participants. The regional IPDN project in Central America has maintained very good communication among hub and spoke labs during Year 4. There is an excellent relationship among labs especially with labs in Honduras (Zamorano and FHIA) and El Salvador (CENTA). Regional coordinator M. Arevalo visited both CENTA and FHIA in 2009. The project has been very successful in maintaining efficient communication channels with plant pathology diagnostic labs within the region covered by the project. Agroexpertos leadership in creating a regional plant disease system through the IPDN project has been successful.

East Africa: In order to position itself to handle diagnostic demands from the East African region, the IPDN hub laboratory at the Kenya Agricultural Research Institute (KARI) conducted a two-month internal training course (between January and March 2009) for its staff (mainly the scientists/diagnosticians, technologists and other support staff). The aspects covered included selected topics relevant to pathological analysis in bacteriology, mycology, virology and nematology. The facilitators were the institute's research scientists who displayed great capacity and resourcefulness. Certificates of achievement were issued after testing and evaluation of participants during the course (Appendix A). This created a strong sense of teamwork and enthusiasm to carry out plant disease diagnostics processes. Efficiency in service delivery has since been witnessed and customer satisfaction improved greatly.

Interations have continued with representatives from institutions participating in the IPDN project in eastern Africa, with the result of more diseased samples being received from Kenya (hub laboratory country) for diagnosis.

West Africa: Three spoke labs were established in West Africa during the reporting period. These are in Senegal (University of Thies; Lab Director: Dr. Papa Madiallacke Diedhiou), Ghana (University of Ghana, Legon; lab Director: Eric W. Cornelius), and Mali (World Vegetable Center, Bamako; Lab Director: Issoufou Kollo).

IPDN website

The IPDN website (http://www.IntPDN.org) is up and continues to be populated with information related to the project.

Priority lists of diseases and pathogens of important crops

Central America: During the third IPDN Diagnostic Workshop held in Guatemala in September 2009, the bacterium ***Ralstonia solanacearum*** race 3 Biovar 2, was again determined to be the most important plant pathogen representing a threat to agricultural exports for the United States. This is mainly due to the importance of solanaceaous crops in the area (tomato, pepper, potato) and the increase importance of exporting tomatoes and peppers to the USA. Another concern is the imminent attack by the disease citrus greening (Huanglongbing) caused by the bacterium *Candidatus liberibacter* and transmitted by a psyllid (Homoptera).

East Africa: Key pathogens and insect pests from the priority list identified in Year 3 were selected for further work and standard operating procedures were developed (See Activity 2.3 below).

West Africa: A survey of *Ralstonia solanacearum* in tomato in Benin was published as a disease note in the international journal *Plant Disease* (see Publications section above).

Development of new standard operating protocols (SOPs)

Central America: The SOP for *Ralstonia solanacearum* is still being developed and the work is 60% completed.

East Africa: Draft SOPs for banana xanthomonas wilt, banana bunchy top disease, bean root rots, fruit flies and fusarium wilt of bananas have been developed. This has involved an interactive process whereby teams formed during the plant diagnostics workshop held in Makerere University, Kampala, Uganda in Year 3 have used agreed templates to reflect the name of the pest/problem to be diagnosed, background (significance of the problem, brief literature review, symptoms, etc), protocols on sample collection, processing and despatch (safe submission), sample receipt and examination, sample storage (in preparation for analysis), screening and confirmation (authority), and relevant annexes.

The process culminated with a workshop was held in June 2009 at the Kenya Agricultural Research Institute (KARI), Nairobi, Kenya to revise and refine the draft SOPs that were initiated during the last project year. During the workshop, the draft SOPs were discussed and refined by selected members of the SOP development groups. The workshop process involved the use of relevant materials in form of hard copies and/or electronic versions of published and unpublished material in books, journals, conference proceedings, online literature searches, etc. After incorporating the suggestions agreed during the refinement workshop, group leaders have now submitted the refined documents for reading and further editing. An additional SOP has also been drafted for gray leaf spot disease of maize.

Analysis of diagnostic capacity in each region

In order to better utilize the regional and local capacity for disease diagnosis, it is necessary to collect information on diagnostic capacity currently available in the 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, in East Africa in 2008 and West Africa in 2009. Results were used as a part of an invited presentation (Banana 2008 Conference, Mombasa, Kenya) and paper to be published in Acta Hort. regarding IPDN capacity building.

West Africa: During the Mali Plant Disease Diagnostic workshop, data were collected on the extent of diagnosis facilities available and services provided by the institutions where the participants of the workshop employed. Institutions providing this information were:

Crop Protection and Plant Biotechnology Lab, Togo
ISRA CRZ/KOLDA, Senegal
Kollo Plant Pathology and Nematology Lab, Niger
Laboratoire de Defenses des Cultures, Benin
Laboratoire de Phytopathologie, Benin
Laboratoire de Phytopathlogie du CDH, Senegal
Laboratoire de Protection des Culture/ENSA, Senegal
Plant Pathology and Weed Laboratory of DPV, Senegal
Laboratoire de Virologie et de Biotechnologie Vegetale, Burkina Faso
Laboratoire de Diagnostic des Maladies Vegetales (LDMV), Mali
Laboratoire des Semences, Mali
Kwame Nkrumah University of Science and Technology, Ghana
Oil Palm Research Institute, Ghana
Pathology Laboratory, University of Ghana, Ghana
Plant Pathology Lab, CRI, Kumasi, Ghana
Pests Diagnostic Lab, The Gambia
Plant Disease Diagnostic Lab, Ahmadu Bello University, Nigeria

Information gathered during the survey included the following: availability of key equipment and supplies (with their names), staffing in the diagnostic lab, average number of samples received for diagnosis annually and number diagnosed, description of clientele, proportion of samples received for phytosanitary compliance or disease management, whether any fee is charged for diagnosis, extent of compliance to standards, and major bottlenecks in discharging the function of diagnosis.

Central America: The Central America region has improved its diagnostic capacity especially in molecular techniques to identify viral diseases. Still, phytobacteriology expertise is needed and the project will try to organize a workshop during 2010 in this important area.

The Central America IPDN hub lab completed an evaluation of diagnostic capacity among participating laboratories in the region. The results are summarized as follows:

Guatemala:
Universidad del Valle (UVG, Private University):
Strengths: Molecular diagnostics of viruses, PCR technique.
Needs: Molecular materials and supplies, Bacteriology training.
Personnel: 2 MS, 4 Bach. Science.
Universidad de San Carlos (USAC, National Public University):
Strengths: Fungi, bacteria and Nematode ID.
Needs: Molecular materials and supplies, training, communications
Personnel: 2 PhD, 1 MS, 4 Bach. Science.
Universidad Rafael Landivar (URL, Private University):
Strengths: Fungi and Entomology
Needs: General materials and supplies, training, communications
Personnel: 2 PhD, 2 MS, 3 Bach. Science.
Agroexpertos
Strengths: Fungi, Nematodes, Entomology.
Needs: Bacteriology and molecular techniques, training.
Personnel: 1 PhD, 1 MS, 2 Bach. Science.

El Salvador:
CENTA (Ministry of Agriculture)
Strengths: Fungi, Nematodes, Insects and weeds.
Needs: Bacteriology and molecular techniques, communications, training.

Personnel: 1 MS, 3 Bach. Science.

Honduras:
FHIA (Honduran Fund for Agricultural Research, Private)
Strengths: Fungi, Nematodes and Entomology
Needs: Bacteriology and molecular techniques.
Personnel: 3 PhD, 4 Bach. Science.
Zamorano (Private University)
Strengths: Molecular Techniques, PCR, Viruses, Entomology
Needs: Bacteriology.
Personnel: 2 PhD, 2 MS, 4 Bach. Science.

Jamaica:
Ministry of Agriculture
Strengths: Molecular Techniques, PCR, Viruses.
Needs: Bacteriology, training.
Personnel: 2 PhD, 2 Bach. Science.

During 2009 the IPDN regional project in Central America collaborated with the insect-transmitted virus global theme project attending a request by Peta-Gaye Chang (Virginia Tech graduate student) and Dr. Sue Tolin for information regarding Virus Diagnostic Capacities within the region. All Hub and Spoke labs answered the diagnostic survey and the information was sent to Dr. Tolin.

Distance Diagnostic and Identification System/Clinic Information Management System (DDIS/CIMS) for IPDN

DDIS/CIMS was developed for IPDN by the University of Florida to assist plant disease diagnosis. The DDIS/CIMS supports users in 12 countries for the IPDN project. Its database contains the most relevant information such as digital pictures of the causal agents, disease symptoms, field information, control methods, and diagnosis from a specialist(s). The Network provides a collaboration and communication tool for IPDN users in various countries and specialists around the world to share information on plant diseases. The system uses field data and digital media as tools for enhancement of diagnosis of plant diseases. Through interactions on the diagnostic network among IPDN users and specialists inside the IPDN or around the world, plant problems can be diagnosed quickly. Specialists can then provide the best management practice recommendations to the users. The system has benefits of early detection of plant diseases from digital samples and diagnosis assistance from specialists anywhere inside the network or around the world. Unlike physical samples, digital samples don’t have governmental restrictions to send across a country boundary.

1) DDIS/CIMS Development. The diagnostic web portal was developed according to the needs of IPDN. After the initial release, the system was reviewed and tested by users. More changes have been made based on feedback and comments from users. Due to the slow Internet connection in Africa, we have modified the webpage design to remove potential download bottleneck to improve system performance. Diagnostic labs/clinics are set up for each of the participating countries. These include lab/clinic director and users. Currently we have set up users for 12 countries from Central America, East Africa, West Africa, and USA. We are continuing to improve and update the system to provide users with new features and functionalities. The diagnostic Web portal is at http://www.intpdnddis.org/ipdn/home.jsp

The system provides the following key features:
a) Role-based web portal
b) Sample can be submitted and diagnostic by a group authorized users
c) Data security management so that samples can only be viewed by authorized users
d) Sample referral to IPDN diagnostician or external experts anywhere
e) Lab and clinic management
f) Sample mapping for authorized users
g) Digital media library for training purpose

Although the Web portal is a user-friendly system, it requires user support to address needs and questions in a timely fashion. In addition, email support is always available to the users. Server hardware and software are also purchased and updated to support the project.

Training users to familiar the DDIS/CIMS is important. A training website was set up so that users can experience the system through an instructor-lead session. On-line FAQs and training videos were developed so that users can learn the system at their own pace.

Central America Region: Testing of the DDIS system in Central America has been difficult mostly due to budget cuts in private and university labs and some personnel changes in the government laboratories. We need to improve in this area end of year 2009 and year 2010 will focus on increasing use of the DDIS system by sending digital samples of important plant diseases in the region. The IPDN regional project leader (Agroexpertos) will focus on this area during the next phase. Annual fees and access to confidential data are concerns from local governments and private labs that need to be resolved.

West Africa Region: Following the Mali workshop, at least three participants used the DDIS to submit samples for diagnosis. During the process, the submitters of samples were further trained on the quality criteria of images and the importance of good description of symptoms while submitting images for digital diagnosis. During the reporting period, national program scientists were helped to identify two important diseases. A papaya fruit rot disease from Niger was tentatively identified as to be caused by *Pythium* species whereas a mango malformation like symptom was reported from Senegal. Mango malformation is a devastating disease not previously reported from West Africa and several *Fusarium* species are implicated in its etiology. While the symptoms are typical of mango malformation, a firm identity of the *Fusarium* species is being pursued. The DDIS continues to be a useful platform for disease diagnosis through a network of experts. Another image of a cotton disease with mosaic symptoms was submitted for diagnosis from Mali.

A mobile plant clinic activity was organized on 21 August 2009 in Zeta-Comè (Calavi: Atlantique) area of Benin. The plant doctor on call was Josephine Hotegni from the Hub lab in IITA Benin. After the clinic was set up, people came with specimens of plants afflicted by diseases and pests. The doctor also visited some farms ornamental nurseries and home-gardens to diagnose disease problems. The following problems were noticed:

Banana: Black leaf streak (aka black Sigatoka caused by *Mycosphaerella fijiensis*) was severe on plants in the home garden of a woman farmer. Her initial perception of the abnormality was that the leaves were scorched under the hot sun. She was advised to strip off the infected leaves so that the inoculum for secondary spread is reduced.

Citrus: A citrus grower's farm was examined and had brown spot disease and mosaic symptoms. The mosaic symptom could not be diagnosed but many aphids were observed on the farm.

Papaya: A home garden owner complained of oozing of gums, yellowing and drying of leaves and reduction of fruit size. Upon comparison with CABI Compendium, the symptoms were identified as those caused by *Erwinia caricae*.


Ananas (pineapple): In a large commercial farm, most ananas plants were healthy but a few plants had root and crown rot symptoms possible caused by a *Phytophthora* species.


Cassava: Another farmer showed her cassava plants which had symptoms of bacterial blight caused by *Xanthomonas axonopodis* pv. *manihotis*.

Regional plant disease diagnostics training workshops

Training was directed toward increasing plant disease diagnostic capacity in spoke laboratories.

Central America: The Central American and Caribbean IPDN project has been very successful in providing high quality plant pathological diagnostic training to key players in the area. In Year 1, a short workshop was held (1 day) following the stakeholder meeting in Antigua, Guatemala. In that session 30 professionals, most of them diagnosticians, were trained in bacteriology, nematology, virology and mycology. During year 2, diagnosticians from Agroexpertos (Guatemala), CENTA (El Salvador) and Zamorano (Honduras), participated in the Plant Diagnostic International Workshop held in Wooster, Ohio. This 2 week intensive course provided a first class theory and hands on training covering not only molecular techniques for plant pathogen identification, but also traditional plant pathology methods using keys and internet information. In Year 3, the second IPDN diagnostic workshop was held in Guatemala City, July 7-11, 2008. This event put together all key regional institutions/labs that work in plant diseases diagnostics. Thirty-five (35) professionals from Guatemala, El Salvador, Honduras and Jamaica were trained in the identification of plant pathogens including bacteria, virus, nematodes and fungi. In addition, special sessions were included in entomology. In Year 4 the third Central American IPDN Diagnostic Meeting was held in Guatemala City at Universidad Rafael Landivar during September 17-18, 2009. Report of this workshop follows. This is the first regional training program within the IPDN conducted solely by local resource persons, a considerable achievement in capacity building by this project.

The Third Central American IPDN Diagnostic Workshop, Guatemala City September 17-18, 2009.

The training was carried out in Guatemala City, at Universidad Rafael Landivar (URL) where the mycology, nematology, bacteriology and virology sessions were conducted. Twenty participants (13 men, 7 women; Appendix B) from the region representing virtually all institutions and labs working in plant disease diagnostics attended the meeting. Diagnosticians from Guatemala, Honduras and El Salvador took part in the event (see list of participants). The IPDN project funded all participants.

A bacteriology session was conducted by Dr. Marco Arevalo from Agroexpertos and Dr. Edin Orozco a plant pathologist from San Carlos University (FAUSAC). Important bacterial pathogens in the region were discussed as well as basic and introductory information. Bacterial pathogens such as *Ralstonia solanacearum*, *Acidovorax avenae*, *Erwinia* spp., *Candidatus Liberibacter* and *Clavibacter michiganensis* were discussed.

A mycology session was led by Dr. José Melgar from FHIA, Honduras. Important fungal pathogens in the region were discussed as well as basic and introductory information. Among important fungal pathogens are *Fusarium oxysporum* (solanaceous crops), *Monosporascus cannonballus* (cucurbits), *Phytophthora infestans* (tomatoes and potatoes), *Rhizoctonia solani* and others. Dr. Melgar pointed out the threat of a new *Fusarium oxysporum* species still not present in banana growing areas of the continent: Central America, South America and the Caribbean. If this species of *Fusarium* invades banana growing areas and the result will be devastating.

A nematology session was led by Dr. Javier Diaz from FHIA, Honduras. Dr. Diaz' training is in Entomology but at FHIA he is in charge of both entomology and nematology departments. Identification tips for important genera and *Meloidogyne* and *Pratylenchus* spp. as probably the most important plant parasitic nematodes in this region, as well as sampling methods were extensively discussed.

A virology session was led by Dr. Margarita Palmieri from UVG. Dr. Palmieri also works with the Insect-Transmitted Virus global theme of the IPM CRSP (leader Dr. Sue Tolin) and this was an important example of IPM-CRSP global theme cooperation. Important diagnostic techniques used for virus identification at the UVG lab such as PCR, ELISA and Blot dot were discussed.

Two sessions, a DDIS and a SOP session, were conducted by Dr. Marco Arevalo (Agroexpertos). It was a reminder that DDIS is a powerful key technology that is very useful for distance diagnosing and communication with experts. The SOP session was very important because especially government officials expressed their interest in working with this type of system in order to be prepared in the event of an introduction of a quarantine disease or pest. All countries in the region lack this kind of capacity. It was agreed to have a specific meeting for SOP discussion in November, 2009.

All participants were very much satisfied with the quality of training, experts and teaching materials. They asked for more training but now focusing in specific plant pathogen groups, for example, to have a workshop exclusively in plant pathogenic bacteria which was again pointed out as a weakness in all laboratories.

Nematology manuals (Practical Plant Nematology: a Field and Laboratory Guide) were distributed to the participants (diagnosticians) at this workshop. This excellent working tool was provided by Mr. Danny Coyne from IITA with funds from IPDN. The Central American region greatly appreciated the effort in translating the document into the Spanish language. The title in Spanish is: Nematología Práctica: Una Guía de Campo y Laboratorio.

Other Collaborative Training Programs in Central America

University of Florida-USDA-FAS (USAID) in Guatemala:

In March of 2009, Carrie Harmon (University of Florida-IFAS) and member of the IPDN global theme project requested a special collaboration in training personnel from the Ministry of Agriculture national lab (MAGA). Carrie Harmon was in charge of the phytomycology, and general plant pathology training and Dr. Marco Arevalo, IPDN regional coordinator, trained participants in nematology. This training was carried out at the headquarters of MAGA near Guatemala City, and about 15 diagnosticians were trained.

Collaboration with Dr. Paula Agudelo (Clemson University, South Carolina) APS-OIP Global Experience Plant-Parasitic Nematode Identification Workshop:

A grant proposal was submitted by Dr. Paula Agudelo (Clemson University) and Dr. Marco Arevalo (IPDN and Universidad Rafael Landivar) to the American Phytopathological Society office of International Programs (APS-OIP) Global Experience program. The objective was to organize the Clemson University Nematode (Internationally known, and probably the best in the world) Workshop in Universidad Rafael Landivar in Guatemala City. The proposal was approved by the APS-OIP committee and the Plant Parasitic Nematode Identification Workshop was held in Universidad Rafael Landivar (Guatemala City) June 16th-20th 2009. Participants included private and public universities, government and quarantine diagnostic laboratories (MAGA and OIRSA) and private labs. Doctor Agudelo showed excellent knowledge and teaching experience in plant nematode biology and identification techniques.

Universidad Rafael Landivar and the IPDN project were important factors in the success of the Workshop. A poster describing the workshop was displayed at the annual APS meeting in Portland, OR in July 2009.

East Africa: The regional activity in Year 4 in East Africa was the SOP development workshop conducted in Nairobi, Kenya.

West Africa: The West Africa International Plant Diagnostic Network Workshop was held in Bamako and Samanko, Mali from 16-20 February, 2009 in cooperation with IER, the Malian national program. IPDN members from AVRDC organized and conducted the workshop with assistance from IITA. The workshop was a big success and involved an impressive group of participants from nine West African countries. The workshop was well-received by the participants and should serve as a foundation for efforts to improve diagnostics in West Africa in the new IPM CRSP project. Twenty-five participants (16 men, 9 women) from 10 countries (Benin, Burkina Faso, Cameroon, Gambia, Ghana, Mali, Niger, Nigeria, Senegal, and Togo) were trained in a variety of topics (see program in Appendix C). Dr. Robert Gilbertson (University of California, Davis) and Dr. Pete Vergot (University of Florida) were the key resource persons from the United States in addition to nine others from the Malian national system and IITA. The objectives were to 1) introduce the participants to various approaches used for diagnosis of plant diseases and other pests (e.g., insects and weeds), 2) conduct hands-on activities with samples collected in the field to acquaint participants with the various methods introduced in the lectures and to introduce participants to the DDIS and to sign-up participants so that they can use the system for assistance in diagnosis of samples from their countries.

The workshop combined lectures and hand-on practical diagnosis of disease specimens (mango leaf spot, citrus canker, leaf spot of tomato, okra powdery mildew and virus on cucurbits) collected during a field trip. The field trip helped in training on the importance of examining patterns of disease development in the field that provides some insights into the initial diagnosis. The training in the lab consisted of traditional microscopy techniques and newer methods such as immunostrip, squash blot, and tissue immunoblot technologies. Participants were also taught methods for collecting samples for molecular diagnosis. IPDN-DDIS was introduced to the participants and they learned how to enter data about a plant sample and how to take appropriate photographs with instructions for uploading onto the system. Almost all of the participants were able to register with the DDIS system so that they would be able to submit samples.

Complementary funding for the workshop was provided by the Foreign Agriculture Service of USDA through the IPDN P.I. to support participation of the majority of the

NARS participants and workshop instructors (Appendix D).

Additional Training

Central Asia IPM CRSP: At the request of the Central Asia IPM CRSP, the IPDN project organized and conducted a 2-day Diagnostics Training Workshop in Bishkek, Kyrgyzstan, June 3-4, 2009. Dr. Sally Miller was the training leader, with additional resource persons Dr. George Bird, Michigan State University; Dr. Barry Jacobsen, Montana State University; Dr. Doug Landis, Michigan State University; Dr. Frank Zalom, University of California – Davis and Dr. Mustafa Bohssini, ICARDA. The Workshop covered basic diagnostic approaches to the major pathogen and insect pest groups. The program is provided in Appendix E.

Development of PCR-based diagnostic assay for banana xanthomonas wilt (BXW).
Work conducted to develop a PCR assay for BXW is in press at this writing:

Lewis Ivey, M. L., Tusiime, G. and Miller, S. A. 2009. A PCR assay for the detection of *Xanthomonas campestris* pv. *musacearum* in bananas. *Plant Disease* 93 (in press).

Assays for detection of whitefly- and aphid-transmitted viruses.
The IPDN is working closely with the Insect-Transmitted Virus global theme to identify critical virus problems and improve virus detection/diagnosis capability, primarily in Central America and West Africa.

Evaluation of the AgDia Plant Sap Collection and Testing Kit for Detection of DNA and RNA viruses. The method that we have been using for preparing samples for testing for infection with whitefly-transmitted begomoviruses is the squash blot, in which plant tissues are squashed directly onto nylon membranes. These nylon membranes are then returned to the laboratory where they can be treated and hybridized with begomovirus DNA probes. Alternatively, the squashed tissues on membranes can be used as a source of DNA for PCR (squash blot-PCR). This method has worked well and has been used for the characterization of begomoviruses from West Africa, Latin America and Asia (see publications Zhou et al., 2008; Kon et al., 2009 at the beginning of the report). More recently, AgDia has developed a new method for collection of plant sap for various purposes, including testing for the presence of virus infection. This method involves the generation of plant sap and application onto adsorption strips, which are thin strips or sticks that have a fibrous binding matrix (pad) at the base, on which the sap is applied. This method shows promise for the detection of DNA viruses such as begomoviruses, as well as viruses with an RNA genome.

Detection of begomovirus infection in samples from West Africa. To assess this method for begomovirus detection, we were provided a number of these adsorption strips for evaluation for detection of begomovirus in samples collected in West Africa in September 2009. The samples tested were tomatoes and okra from various locations in Mali that showed begomovirus-like symptoms (Table 1). Sap was prepared and samples were applied to the adsorption strips following the procedure provided by Agdia, except that the sap was prepared using buffer and bags that were provided with AgDia immunostrips. This modification was used based on our preliminary tests performed with RNA viruses. The sap was prepared in a hotel room and put onto the pads of the adsporption strips. The strips were allowed to air-dry and then taped onto index cards. The strips were then transported back to UC Davis where DNA was extracted from the pad using a modified Dellaporta procedure. The DNA extract was then used in the PCR with degenerate begomovirus primers (UPV1/1000C) and primers for detection of betasatellites (the small satellite DNA molecules that are commonly associated with monopartite begomoviruses). The expected size (~1.6 kb) begomovirus fragment was amplified from all three tomato samples with different begomovirus symptoms and from four of five okra samples with begomovirus symptoms (Table 1). The expected size ~1.4 kb betasatellite fragment was amplified from the same four okra samples that the begomovirus fragment was amplified from, but not from any of the tomato samples (Table 1). The begomovirus fragments amplified from two tomato samples (one with symptoms typical of infection with *Tomato yellow leaf crumple virus* [ToYLCrV] and the other with a severe symptom [broccoli] phenotype) and three okra samples with okra leaf curl symptoms were sequenced. From both tomato samples, the sequence of the amplified fragment was 97-98% identical to ToYLCrV, one of the known tomato-infecting begomoviruses in West Africa (Zhou et al., 2008). Furthermore, this result was consistent with one of the samples having symptoms typical of ToYLCrV infection. The severe symptom phenotype can be due to mixed infection of begomoviruses (including ToYLCrV) or a begomovirus and a betasatellite (Chen et al., 2009). The symptoms in this particular plants were probably due to mixed begomovirus infection (i.e., ToYLCrV and another begomovirus, possibly *Tomato leaf curl Mali virus*) based upon the finding of no betasatellite in this plant. In the case of the okra, the sequence of all three of the PCR-amplified fragments was 95-96% identical to *Okra yellow crinkle virus* (OYCrV), a begomovirus known to be associated with okra leaf curl in Mali (Kon et al., 2009). Furthermore, the detection of the betasatellite in all the samples in which OYCrV was detected was consistent with OLCD being caused by a complex of begomoviruses and a betasatellite (Kon et al., 2009).

These results indicate that the adsorption strips can be used for sampling of plants with suspected begomovirus symptoms for subsequent PCR analyses. This could be combined with a new PCR detection method that requires no DNA extraction step. Further testing needs to be done with additional plant species from other locations, but these results are very encouraging and this method should compliment the squash blot method. Note that the squash blot method represents an alternative to PCR-based methods as one can use hybridization with DNA probes to detect begomovirus nucleic acids. Furthermore, the fact that the AgDia Plant Sap Collection and Testing Kit method worked with okra, a malvaceous host with mucilaginous sap that can be difficult to use in the SB-PCR method, indicates that the utility of this method for a wide variety of host plants.

Detection of RNA viruses. We also assessed the technique for detection of RNA viruses. In initial experiments, we assessed the method for detecting a known virus, *Tomato spotted wilt virus* (TSWV). Sap was prepared using the immunostrip bags and buffer, and applied to the adsorption strips. RNA was extracted according to a method provided by AgDia for extraction of RNA from immunostrips and used in RT-PCR with TSWV primers (tswvN1 and tswvN777). From all three known TSWV-infected samples, the expected ~700-800 bp fragment was amplified. No fragment was amplified from a healthy tomato control. This suggested that this method may be suitable for preparation of sap for detection of RNA viruses.

Further, we tested the method for the detection of cucurbit-infecting viruses in samples collected in West Africa in September, 2009. Samples were collected from a cucurbit field in Baguineda showing three different symptom types: 1) a typical *Zucchini yellow mosaic virus* (ZYMV)-type symptom (strong leaf distortion, strap-leaf symptoms and mosaic), 2) light green interveinal mosaic symptom (potyvirus-like) and 3) a spotting/yellowing symptom that appeared more similar to symptoms induced by the crinivirus, *Cucurbit yellow stunting disorder virus* (CYSDV). Sap was prepared as described above and applied to the adsorption sticks in Mali (in a hotel room), and the sticks were brought to UC Davis. RNA was extracted as described above and two samples of each of the three symptom types were tested for infection with potyviruses or CYSDV by RT-PCR with degenerate potyvirus primer pairs (HcPro primer pair: DegHcProFrw/DegHcProRev and CI primer pair: DegCIFrw/DegCIRev) or a primer pair that amplifies the CYSDV capsid protein sequence (CY-13/CY-14). The expected-sized potyvirus fragments were amplified from extracts of samples with the ZYMV-like symptoms and the light green interveinal mosaic. Sequence analysis of these fragments revealed >90% identity with ZYMV sequences, indicating that both of these symptoms were probably caused by infection with ZYMV. No fragments were amplified from the sample with the spotting/yellowing symptoms with RT-PCR and either the potyvirus or CYSDV primers; thus, it is not clear what is causing these symptoms. However, these results reveal the promise of this sample preparation method for detection of RNA viruses. We also were able to use this method to successfully detect *Rice yellow mottle virus* (RYMV) infection in rice from samples collected in Mali.

Table 1: Samples prepared using the Agdia Plant Sap Collection and Testing Kit and tested for begomovirus and betasatellite infection using PCR.

			PCR amplification of expected-size fragment		
Host	**Location**	**Symptoms**	**Begomovirus**	**Betasatellite**	**Sequence**
Tomato	Kati	Typical ToYLCrV	+	-	ToYLCrV (97%)
Tomato	Kati	Typical leaf curl	+	-	ND
Tomato	Kati	Severe symptom phenotype	+	-	ToYLCrV (98%)
Okra	Sikasso	Leaf curl, crumple	+	+	OYCrV (96%)
Okra	Baguineda	Leaf curl, crumple	+	+	OYCrV (96%)
Okra	Baguineda	Leaf curl, crumple	-	-	
Okra	Kati	Leaf curl, crumple	+	+	OYCrV (95%)
Okra	Kati	Leaf curl, crumple	+	+	ND

Abbreviations: ToYLCrV=*Tomato yellow leaf crumple virus*; OYCrV=*Okra yellow crinkle virus*; and ND=not determined.

Integrated management of thrips-borne tospoviruses in vegetable cropping systems

Naidu Rayapati, Washington State University

Documentation of viruses in vegetable cropping systems in India

Gandhi Karthikeyan, S.K. Manoranjitham, Gopinath Kodetham, Sudarsana Poojari, Naidu Rayapati

To determine the prevalence of viruses in different vegetable crops, samples suspected for virus-like symptoms were collected from tomato, chilli and bell pepper, cucurbits and egg plant from selected locations in Coimbatore, Dharmapuri and Salem Districts of Tamil Nadu state and Chittoor district of Andhra Pradesh state. Extracts from a total of twenty-seven samples representing these crops from Tamil Nadu were spotted on FTA® Classic Cards and shipped to Rayapati's lab at Washington State University for testing by reverse transcription-polymerase chain reaction (RT-PCR) for different viruses using degenerate primers for CMV subgroup I and II, potyviruses, tospoviruses and geminiviruses. Among the 26 samples, RT-PCR products of the expected size were obtained from 20 samples while the remaining 6 were negative for all viruses tested (Table 1). Of the twenty positive samples, two samples tested positive for geminivirus-specific primers and 18 samples tested positive for CMV subgroup I. Eight of the CMV subgroup I positive samples were also tested positive for potyviruses indicating mixed virus infections in these samples. All samples tested negative for CMV subgroup II and tospoviruses. To confirm these results, RT-PCR amplified fragments were cloned into TOPO TA cloning vector and nucleotide sequence analyses is in progress.

In addition, tomato fruits showing symptoms suspected for tospovirus infections were collected from selected farmers' markets in both states and tested by RT-PCR for the presence of *Peanut bud necrosis virus* (PBNV). The results were further verified by cloning and sequencing of the PCR-amplified DNA fragment and comparing the sequence with PBNV sequence available in the GenBank. These results confirm our previous observations that tomatoes sold in many vegetable markets are infected with PBNV. Further research is being carried out to assess the implications of the presence of tospoviruses in tomato fruits.

Table 1: RT-PCR testing of samples collected from tomato, chilli pepper and cucurbits for the presence of different viruses in Tamil Nadu

S. no.	Crop	Type of symptom	CMV (Sub group I)	Gemini virus	Tospo virus	Potyvirus
1	Tomato	Tospo like symptom	-	+	-	-
2	Tomato	leaf curl	-	+	-	-
3	Tomato	Mosaic motling	-	-	-	-
4	Tomato	Mosaic motling	+	-	-	-
5	Coccinia	Mosaic symptoms	+	-	-	-
6	Snake gourd	Mosaic	+	-	-	-
7	Pumpkin	Mosaic	+	-	-	+/-
8	Ridge gourd	Mosaic	-	-	-	-
9	Chilli	Necrosis	+	-	-	+
10	Tomato	Bronzing	-	-	-	-
11	Chilli	Interveinal chlorosis	+	-	-	+
12	Tomato	Mosaic motling	+	-	-	-
13	Tomato	Shoe string	+	-	-	-
14	*Solanum nigrum*	Chlorotic spots and mosaic	+	-	-	+
15	Bell pepper	Mosaic and vein banding	-	-	-	-
16	Bell pepper	Mosaic motling	-	-	-	-
17	Bell pepper	bronzing	-	-	-	--
18	Chilli	Mosaic motling	+	-	-	+/-
19	Chilli	Mosaic motling& Leaf size reduction	+			+
20	Snake gourd	Mosaic	+	-	-	-
21	Brinjal	Young leaf bronzing	+	-	-	-
22	pumpkin	Shoe string symptom	+	-	-	+
23	pumpkin	Mosaic	+	-	-	+
24	Tomato	necrosis	+	-	-	-
25	pumpkin	Mosaic motling	+	-	-	+
26	Chilli	Stem necrosis	+	-	-	+

A total of 397 tomato samples were collected from seven different villages in Madanapalli area of Andhra Pradesh. Samples were tested by ELISA using antibodies to PBNV, *tobacco streak virus* (TSV), *Cucumber mosaic virus* (serogroup I), *Tomato mosaic virus* (ToMV) and group-specific antibodies to potyviruses. Each sample was tested separately with antibodies specific to each virus and the results are shown in Table 2.

Table 2: ELISA testing of tomato samples for the presence of different viruses in Madanapalli area, Andhra Pradesh.

Field number	**No. of tomato samples collected**	**PBNV**	**TSV**	**CMV (sub-group I)**	**ToMV**	**Potyvirus**
1	72	33	13	11	10	5
2	54	26	11	5	5	7
3	57	14	2	6	32	3
4	44	6	9	6	21	2
5	74	24	19	12	16	3
6	43	13	9	7	8	6
7	53	17	15	9	7	5
Total	397	133 (34%)	78 (20%)	56 (14%)	99 (25%)	31 (7%)

The test results indicate presence of several viruses, with PBNV, TSV and ToMV accounting for the most predominant viruses. Further analysis of the results indicated that PBNV and TSV are present across all locations, whereas the other three viruses were detected in samples from a few fields. In addition, we observed mixed infection of PBNV and TSV in nearly 50% of samples that tested positive for either of the two viruses. In a few fields at specific locations, tomato plants were largely tested positive for ToMV and the incidence was close to 100%. High incidence of ToMV could be due to its seed transmission. It is not clear, however, if ToMV is spread through seed purchased from commercial entrepreneurs.

A new virus disease epidemic in yardlong bean crops in Indonesia

Tri Damayanti, Olufemi Alabi, Aunu Rauf and Naidu Rayapati

Yardlong bean , native of Southeast Asia, is extensively cultivated in Indonesia for consumption as a green vegetable. During 2008, a severe outbreak of a virus-like disease occurred in yardlong beans grown in West Java and Central Java. The leaves of symptomatic plants showed indications of severe mosaic to bright yellow mosaic and vein-clearing, and pods produced by these plants were deformed with mosaic symptoms on the surface. The disease incidence averaged 80% resulting in 100% yield loss. Symptomatic leaf samples from yardlong beans tested positive in antigen coated plate ELISA with potyvirus group-specific antibodies (AS-573/1; DSMZ, German Resource Center for Biological Material, Braunschweig, Germany DSMZ) and antibodies to *Cucumber mosaic virus* (CMV, AS-0929). Phylogenetic analysis of BCMV isolates from Indonesia showed clustering with corresponding isolate from Taiwan, suggesting that Indonesian isolates are more closely related to BCMV from Taiwan and distantly related to those from China and USA. In contrast, the CMV isolates from yardlong bean (FJ687054) showed 100% identity among themselves and 96% identity with corresponding sequences of CMV subgroup I isolates from Thailand (AJ810264) and Malaysia (DQ195082). These results confirmed the presence of BCMV and CMV in symptomatic leaves of yardlong beans. Previously, BCMV was documented on yardlong beans in Guam. Our study confirms the occurrence of BCMV in yardlong beans in Indonesia.

Optimization of protocols for thrips transmission of tospoviruses

David Riley and Anitha Chitturi

IYSV transmission by *Thrips tabaci*

In a series of experiments, *Iris yellow spot virus* (IYSV) transmission efficiency by *Thrips tabaci* in onions was investigated on the Tifton Campus of the University of Georgia. IYSV-infected sprouted onion bulbs heavily infested with *Thrips tabaci* were collected from an onion packing shed just south of Reidsville, GA. The infested onion bulbs were potted in 4-inch pots using ‘LT 5 Mix’ and maintained in a greenhouse. Onion bulbs with viruliferous thrips were maintained in the green house and allowed to grow until symptoms appeared on the plants. Onion plants were tested with DAS ELISA and *T. tabaci* adults collected from IYSV positive plants were used for transmission bioassays. Healthy onion setts were procured from Arizona and the sprouted seedlings were tested with DAS ELISA before using them for actual transmission studies. Seedlings that tested free of the virus were placed into 20 × 150mm glass test tubes, and wrapped with a wet cotton ball to provide enough moisture. Four viruliferous thrips (*T. tabaci)* adults were placed on each onion seedling and allowed to feed for 24 hours before they were collected and placed in 1X PBST buffer. Seedlings were maintained in the test tubes for 2 weeks with the adition of vermiculite and later tested with DAS ELISA for the presence of virus.

***Thrips tabaci* settling and oviposition**: Settling and ovipositional behavior of *Thrips tabaci* were observed by setting up a whole-plant bioassay using an insect cage measuring 47.5×47.5× 47.5 cm. Onion seeds cv. Pegasus Hybrid Onion were placed in germination trays and allowed to germinate until two leaf stage in growth chambers at 25° C. The seedlings were then transferred to the green house and transplanted into 4-inch pots using 'LT 5 Mix'. Plants were watered on alternate days and visually checked to ensure that they remained insect-free. Four adult females of *T. tabaci* were released on 2-3 leaf onion plants placed in individual insect cages. To quantify the settling behavior, thrips position on the leaf were recorded for every 30 minutes for 4 hours for 5 days. For oviposition, thrips were allowed to oviposit for 5 days. Oviposition sites were counted by following the lactophenol acid fuchsin staining technique. The intact leaf tissues were pinched from each plant and recolorized by boiling 3-5 minutes in the lactophenol acid fuchsin solution. Stained leaves were cooled for 3-5 hrs and excess stain was removed with warm water and then examined under a stereo microscope for oviposition sites indicated by purple rings.

Thrips tabaci oviposition occurred towards the base in both young and older plants. Laboratory bioassay results confirmed field results, showing a general preference for oviposition of thrips toward lower portions of the leaf just above where the leaf sheath wraps tightly around the new leaves which emerge from the base of the plant.

IYSV Transmission by *Thrips tabaci*

We were successful in establishing an unusually high level of virus infection in a *Thrips tabaci* lab colony (70 to 80%) and determining that very low numbers of *Thrips tabaci* can transmit IYSV (Table 3). Unfortunately from the standpoint of IYSV management, these tests also demonstrated that transmission of IYSV can occur in as little as 15 minutes feeding time on the onion plant.

Transmission rates of IYSV were determined by first using different population densities of Thrips tabacy adults at a single exposure time of 5 days and then at a set population density of four adults (estimated 70 to 80% viruliferous) at different exposure times on 3 to 4-leaf stage on ions.

Table 3: IYSV transmission rates

Population Density Treatments	***% IYSV transmission****	**Exposure Time Treatments**	***% IYSV transmission****
0 adults	0%	0 minutes	0%
1 adult	80%	15 minutes	73%
4 adults	91%	30 minutes	82%
8 adults	89%	1 hour	60%
12 adults	85%	6 hours	88%
		24 hours	79%

* Onion plants were tested with DAS ELISA 5 days after the thrips treatment.

Diagnostic methods for the detection of vegetable viruses

Naidu Rayapati, Sudarsana Poojari, Gopinath Kodetham, Tri Damayanti, Manoranjitham Karuppannan, Olufemi J. Alabi, Gandhi Karthikeyan, P. Lava Kumar and Aunu Rauf

Detection of tospoviruses in single thrips

Since virus detection in single thrips by serological techniques like ELISA using virus-specific antibodies is not reliable due to small size of thrips, we have developed an RT-PCR assay for the detection of tospoviruses in single thrips. We used two tospoviruses (*Tomato spotted wilt virus* [TSWV] and *Impatiens necrotic spot virus* [INSV]) and western flower thrips (WFT, *Frankliniella occidentalis*) for optimization of conditions for the detection of tospoviruses in single thrips. Synchronous-aged (4-h-old) first-instar larvae of WFT were allowed to feed on TSWV- or INSV-infected *Emilia sonchifolia* [(L.) DC. Ex Wight] leaves. After a 24 h acquisition access, the larvae were transferred from symptomatic leaves to green bean pods and reared to adults. These potentially viruliferous adult thrips were used for virus testing. Individual thrips were ground in 10 µl of GEB buffer and 2 µl of the extract was mixed in 10 µl GES buffer, denatured at 95°C for 10 minutes and used for virus detection by RT-PCR using species-specific primers. In addition, thrips samples stored in 80% ethanol at room temperature were tested for the presence of TSWV using the same extraction protocol described above. As shown in Figure 1, TSWV and INSV can be detected in single thrips by RT-PCR using the simple extraction method. In addition, we were also able to detect TSWV in thrips stored in ethanol (Figure 2). The DNA fragment amplified from single thrips was cloned and sequenced, and the derived sequences were confirmed by comparing the corresponding sequences in GenBank. Using this protocol, we were able to confirm the presence of TSWV in single thrips collected from Guatemala and preserved in 80% ethanol in collaboration with Dr. Margarita Palmieri, Departamento de Biología, Universidad del Valle de Guatemala, Guatemala. The practical advantage of this method is that different species of thrips in vegetable crops can be collected in the field, stored in ethanol and transported to a central location for the detection of virus. The other advantage is that the same extraction protocol that we have used for testing virus in fresh plant samples and samples spotted on FTA® Classic Cards can be used for extraction of nucleic acids from thrips samples (fresh or preserved in 80% ethanol) for virus detection.

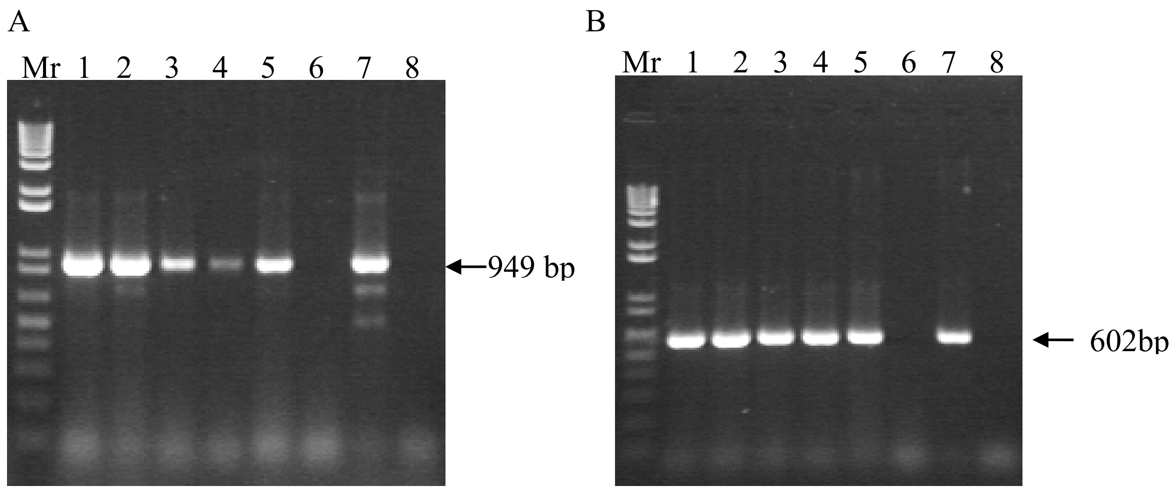


Figure 1: RT-PCR detection of TSWV (A) and INSV (B) in single thrips. Lanes 1-5 represent viruliferous thrips and lane 6 represent non-viruliferous thrips. Positive and negative controls are included in lanes 7 and 8, respectively for TSWV (A) and INSV (B). Lane Mr represents molecular weight marker (1 kb Plus DNA ladder, Invitrogen) to estimate the 949 bp and 602 bp fragments, specific to TSWV and INSV, respectively.

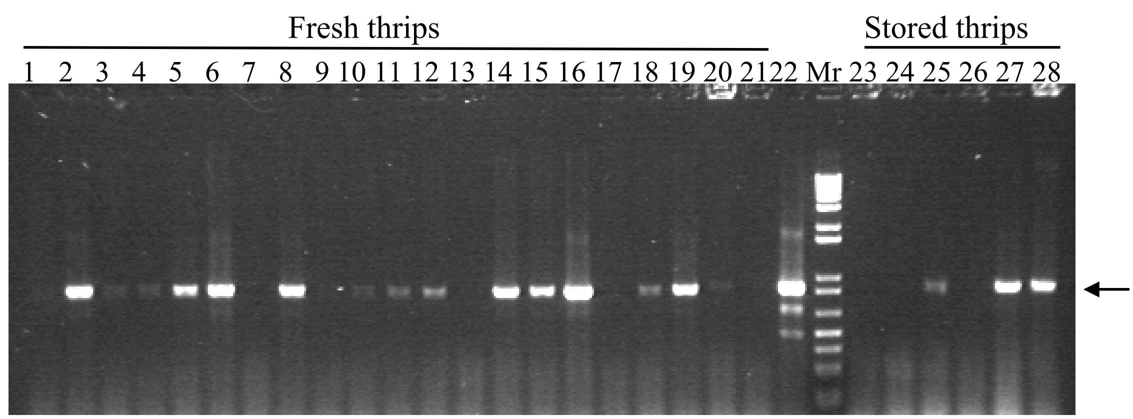


Figure 2: RT-PCR detection of TSWV in single thrips. Lanes 1-20 represent viruliferous thrips, lane 21 represent non-viruliferous thrips and lane 22 represents TSWV-infected plant samples that served as a positive control. Lane Mr represents molecular weight marker (1 kb Plus DNA ladder, Invitrogen) to estimate the 949 bp fragment specific to TSWV, represented by an arrow on the right side. Lanes 23-28 represent thrips stored in ethanol and tested for TSWV.

Diagnosis of plant viruses using FTA Classic Card technology

We evaluated the usefulness of FTA cards for the collection, shipment and identification of viruses in different crops. Plant samples suspected for virus infections were collected from tomato, chili pepper, cucumber, yardlong bean, cassava and weed hosts in farmer's fields in India, Indonesia and Nigeria, pressed on FTA cards and shipped to Rayapati's lab at Washington State University. A simplified method was optimized for eluting the captured nucleic acids from the FTA Cards. The nucleic acid extracts were subsequently used for RT-PCR amplification of virus-specific genomic segments (Fig. 3). The amplified DNA was cloned and sequenced, the sequences obtained from cloned DNA fragments were compared with corresponding sequences in the GenBank. Using FTA Classic Card technology, we were able to detect a broad range of viruses (viz. *Bean common mosaic virus*, *Chilli veinal mottle virus*, *Papaya ring spot virus*, *Tomato spotted wilt virus*, *Peanut bud necrosis virus*, *Cucumber mosaic virus*, *African cassava mosaic virus* and *East African Cassava mosaic Cameroon virus*) in a variety of samples collected from different crops and weeds in several countries of Asia and Africa.

Since viral nucleic acids bound to FTA® cards are inactivated, there is no risk of introducing alien pathogens in other countries. FTA cards spotted with samples can be stored at room temperature for an extended period of time to preserve viral nucleic acids. These results, therefore, illustrate the practical value of FTA card technology in disease surveys and other downstream applications for the diagnosis and molecular characterization of a broad range of plant viruses.

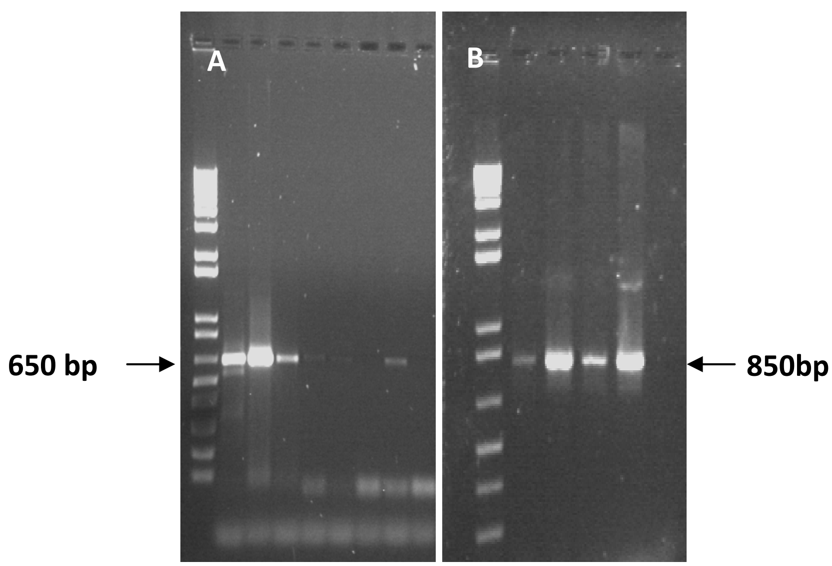


Figure 3: Detection of *Cucumber mosaic virus* (A) and *Peanut bud necrosis virus* (B) by RT-PCR from total nucleic acids eluted from FTA® cards. Field samples were initially spotted on FTA cards and brought to the lab and stored at room temperatures before using for virus diagnosis.

Evaluation of tomato cultivars and hybrids against *Peanut bud necrosis virus*

Gandhi Karthikeyan, S. Deepa and Naidu rayapati

Our studies have indicated that *Peanut bud necrosis virus* (PBNV) has become a major limiting factor in recent years for tomato production in India. Due to lack of sources of host-plant resistance, field evaluation of existing cultivars and hybrids will enable assessment of the impact of PBNV on field performance of commercially available tomato cultivars and hybrids and make recommendations for farmers, in the short term, to grow suitable cultivars and/or hybrids.

For this purpose, a field trial was conducted during the Rabi growing season (January-May, 2009) to evaluate the field performance of the tomato cultivars/hybrids in hot-spot areas of Tamil Nadu. These cultivars/hybrids (both public and private) were selected because they are commonly grown by farmers in Tamil Nadu state. These cultivars/hybrids are: Ruchi, Kushi, JEM, US Rudra, Lakshmi, Apoorva, Sakthiman, US 618, PHS, Abinav, Rajadhani, 3618, PKM-1, COTH-2 and H24. The seeds of the above fifteen tomato cultivars / hybrids were treated with the bioagents *viz., Pseudomonas fluorescens* – PF1, *Bacillus subtilis* and *Trichoderma viride* @ 10 g/ Kg of seeds and raised under shade net conditions in collaboration with a farmer in Krishnagiri district. The tomato seedlings were transplanted in a randomized block design with five replications. There was no incidence of any of the viral diseases like bud necrosis and leaf curl at the time of transplanting of tomato seedlings. Subsequent to transplanting, each cultivar was observed for bud necrosis and leaf curl symptoms and incidence of each disease was recorded at biweekly intervals. Final data on the incidence of both bud necrosis and leaf curl is presented in Fig. 4. The results showed that cumulative incidence of bud necrosis and leaf curl disease was variable among different cultivars/hybrids in this trial. However, the overall incidence of bud necrosis is relatively higher than leaf curl disease.

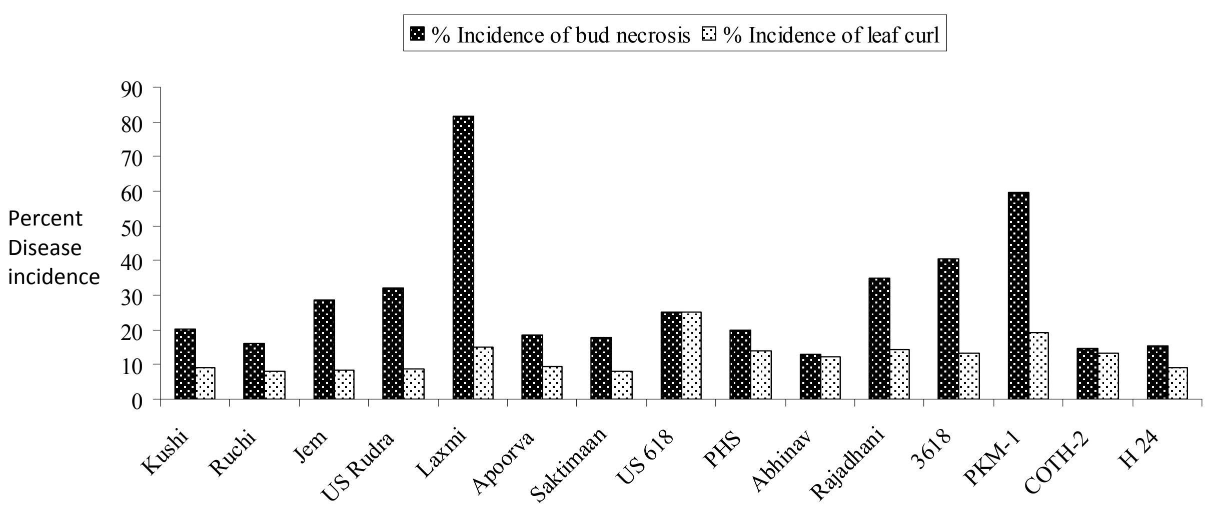


Figure 4: Field incidence of bud necrosis (caused by thrips-transmitted *Peanut bud necrosis virus*) and leaf curl (caused by whitefly-transmitted *Tomato leaf curl virus*) in 15 cultivars/hybdrids. The observations were made based on visual symptoms.

Individual plants in this trial were monitored for thrips and whiteflies 45 days after planting. The average number of thrips per plant ranged between 7 and 22 in different cultivars, and the average number of whiteflies per plant ranged between 2 and 14 in different cultivars. There was no significant difference in number of thrips and whiteflies per plant, suggesting that difference in disease incidence among the fifteen cultivars/hybrids could be due to the virus itself and not insect vectors.

At the end of the season, weight of tomatoes harvested from each of these cultivars/hybrids over the season was pooled and cumulative harvest data as yield (tons per hectare) was recorded. The results showed that cumulative yield of tomatoes, indicative of field performance of cultivars/hybrids, is variable. However, cultivars like Laxmi that are susceptible to bud necrosis performed very poorly. Bud necrosis and leaf curl disease was variable among different cultivars/hybrids in this trial.

Spatial and temporal distribution of PBNV in tomato

As part of developing IPM tactics for the management of bud necrosis disease caused by PBNV, we initiated studies to monitor spatio-temporal distribution of the disease in farmer's fields. Two fields of tomato, one in Coimbatore district and another in Dharmapuri district were monitored for spatial and temporal spread of the disease. In both fields, farmers have transplanted tomato seedlings (cvs. Sakthiman and 5005) purchased from nurseries. The number of symptomatic tomato plants based on visual symptoms was mapped at biweekly intervals in both locations. As shown in Fig. 5, spatial and temporal spread of PBNV in one tomato filed over a two and half month period has increased from 7.1% to 29.9%. In another location, the disease incidence during the same period has increased from 8.2% to 33.5%. The spatial distribution of symptomatic plants (Figure 5, right) suggest that the spread of disease by thrips occurs mostly either to the neighboring plants in the same row or to the plants at adjacent rows leading to clustering of infected plants. These results indicate that infected transplants can serve as a source of primary inoculum for secondary spread of the disease. Thus, rogueing of infected seedlings during transplanting, as shown in Fig. 7, could be used to prevent the introduction and subsequent spread of the disease.

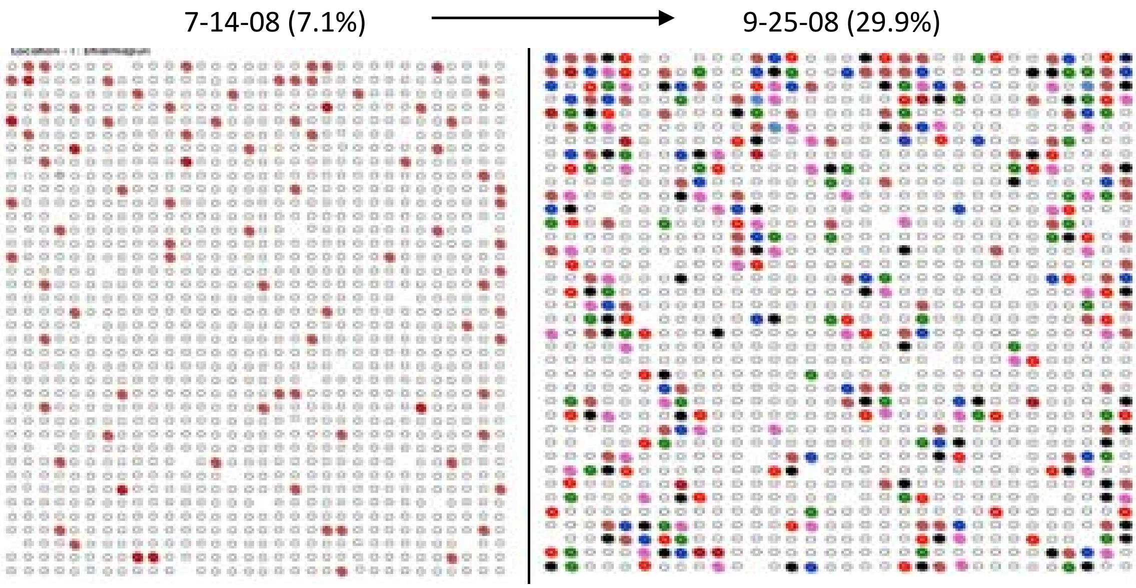


Figure 5: Spatial and temporal spread of tomato spotted wilt disease caused by PBNV in tomato field. Random distribution of infected seedlings (left) serve as a source of inoculum for secondary spread of the disease resulting in clustering of infected plants (right). Each color represents observations at bi-weekly intervals beginning July 14 and ending September 25.

Evaluation of rogueing as a management tactic against bud necrosis disease in tomato caused by *Peanut bud necrosis virus*

Gandhi Karthikeyan, S. Deepa and Naidu Rayapati

For the evaluation of rogueing as a management practice against bud necrosis disease in tomato caused by *Peanut bud necrosis virus* (PBNV) in India, field trials were conducted involving tomato hybrids 5005 and S44 in one location in Coimbatore district, and one trial involving cultivar US 618 in Krishnagiri District of Tamil Nadu. Each of these trials were divided into two halves and in one half, all seedlings suspected for infection with PBNV were removed at the time of transplanting (designated as 'rogued plot') and in the other half, the seedlings were planted as such without sorting symptomatic seedlings (designated as 'unrogued plot'). The incidence of bud necrosis disease was monitored at bi-weekly intervals (Figure 5) and the cumulative end of season.

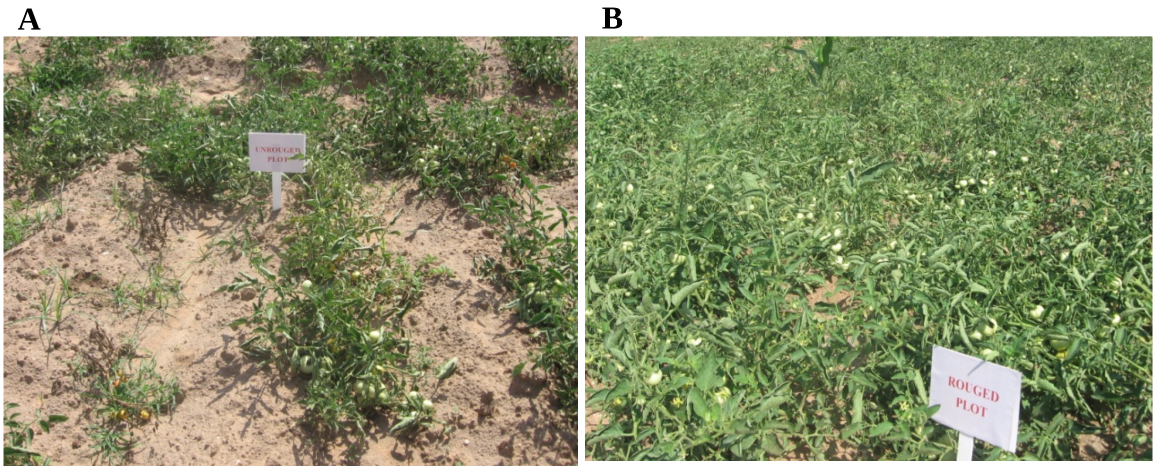


Figure 6: A comparison of unrogueing (A) and rogueing (B) as a strategy to minimize the impact of spotted wilt disease in tomato cultivar US 618 caused by PBNV.

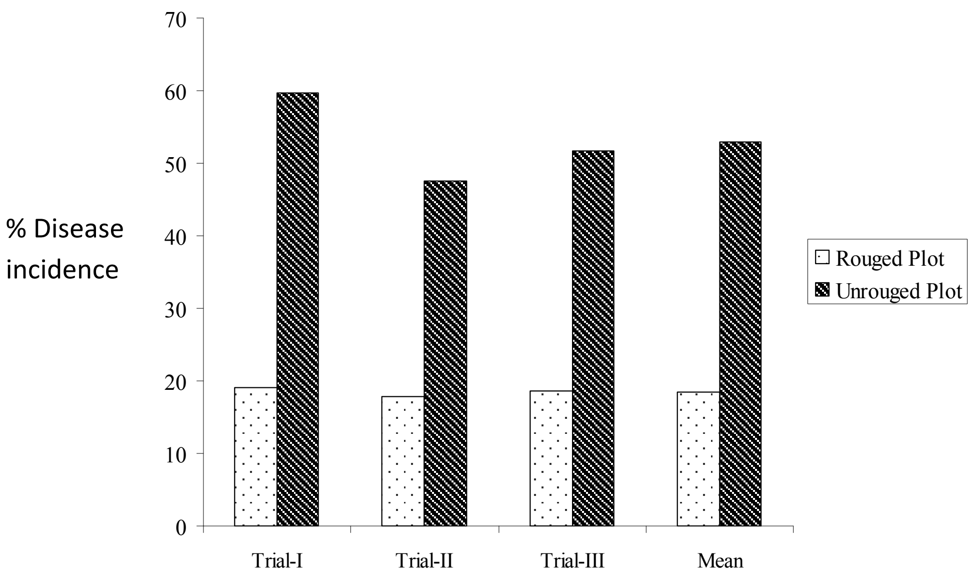


Figure 7: Effect of rogueing on cumulative incidence of PBNV in tomato in all three trials, the cumulative incidence of PBNV is less than 20% in plots (light color bars), whereas the incidence was 50% and above in plots without rogueing (dark colored blocks).

The results showed that incidence of bud necrosis disease was significantly high in plots where rogueing was not practiced, when compared disease incidence in plots where rouging was practiced. These results were consistent in all three trials involving two hybrids (5005 and S44) in one location in Coimbatore district and one cultivar (US 618) in another location. A comparative assessment of yield between plots with and without rouging showed that the former approach gave a total yield of 15.42 tons/ha and the later approach gave 10.7 tons/ha. Thus, adopting rouging as a tactic of reducing spread of bud necrosis diseases increased tomato fruit yield by 44 per cent (Figure 8). An analysis of cost benefit ratio revealed that farmers could gain an additional income of Rs. 18,880/= per hectare without any inputs at the time of planting tomato seedlings.

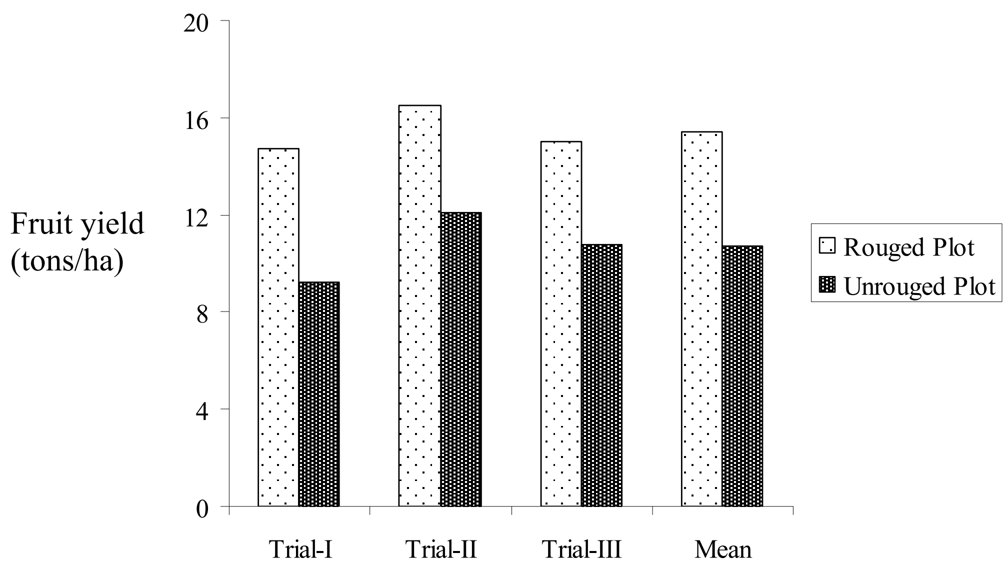


Figure 8: Total yield of tomato in plots with (light bars) and without (dark bars) rogueing.

Genetic resistance against *Peanut bud necrosis virus* in tomato

G. Kodetham, E. Surendra, and S. Poojari

We have established protocols for lab-based resistance screening of tomato lines against PBNV. A culture of PBNV was maintained on cowpea cv. C-152 and *Nicotiana benthamiana*. The virus from these sources was used to screen a limited number of tomato mutant lines (generated through a technique called 'tilling') and other varieties listed in Table 5. Twenty five day-old tomato seedlings were inoculated with PBNV and plants were observed daily for symptom expression. A total of 15 plants were inoculated for each line and equal number of plants was included as control. Percentage of virus infection in each of the tomato lines was calculated by the formula: number of symptomatic plants/ total number of plants inoculated x 100. As shown in Table 4, the susceptible check (Money Maker) showed 100% infection and othe other lines showed percent infection ranging between 25 and 91%. Among the 10 lines screened, Arka alok-30 showed upto 75% resistance and Arka vikas-30 and PED-30 showed upto 69% resistance against PBNV infection. The resistant plants are maintained in the greenhouse for seed collection.

Table 4: Screening of tomato mutant lines against PBNV under greenhouse conditions

S. No.	Tomato Cultivar	# Seeds sown	# Plants inoculated	# Plants infected	% Infection
1	WT [Money maker]-30	15	12	12	100
2	Arka meghali-30	15	5	5	100
3	Pusa ruby-30	15	12	11	91
4	Rutgers LA1090	15	12	11	91
5	EZ-521075	15	12	11	91
6	M82-30	15	15	13	86
7	WT[GT]-30	15	12	10	83
8	Antimold B LA3244	15	12	10	83
9	Arka surabh-30	15	12	10	83
10	kokomo LA 3240	15	11	9	82
11	Lukullus LA0534	15	11	9	82
12	EZ-339058A	15	9	7	78
13	Rheinlands LA0535	15	15	10	67
14	VF 145	15	7	4	57
15	Arka abha-30	15	15	8	53
16	PMK-1[Peria kulam]-30	15	15	8	53
17	Arka vikas-30	15	12	5	41
18	PED[Pusa early dwarf]-30	15	12	5	41
19	Arka alok-30	15	12	3	25

Determination of seed transmission of *tobacco streak virus* in okra

Gandhi Karthikeyan, S. Deepa, Naidu Rayapati

Since *Tobacco streak virus* (TSV) is known to be seed-transmitted in some weed and crop species, we conducted experiment to determine if the virus can be seed-transmitted in okra. This information will be useful to determine if TSV can spread through seed distributed by commercial companies and seedlings from contaminated seed can serve as a source for secondary spread through pollen carried by thrips.

For this activity, symptomatic okra plants infected with TSV were flagged in farmer's fields in Dharmapuri, Salem and Coimbatore districts. The seeds were collected from mature okra fruits produced by TSV-infected plants. Four sets of seeds were sown in pots under greenhouse conditions and observations were made for symptoms on leaves and fruits from seedling stage till pod maturation. The presence of TSV was further confirmed by RT-PCR. As shown in Table 5, an average of 9.9 per cent rate of seed transmission was observed. The results also showed that the rate of seed transmission is higher in hybrid seed from plants with self pollination. Further studies are required to assess the extent of seed transmission in okra and evaluate the risk of dissemination of TSV through seed supplied by commercial entrepreneurs.

Table 5: Rate of seed transmission of TSV in okra seeds

Sl. No.	**Set**	**Cultivar**	**Total no of plants**	**Number of infected plants**	**Per cent transmission**
1	I	Local	300	0	0
2	II	Local	250	7	2.8
3	III	Hybrid	200	58	29.0
4	IV	Hybrid	100	19	19.0
Mean			**850**	**84**	**9.9**

Interactions with Global theme projects and IPM Regional projects

Organized a scientific session "IPM strategies for the management of insect transmitted plant virus diseases" on March 24, 2009, at the 6th International Symposium-Transcending Boundaries (March 24-26, 2008) in Portland, OR, with Sue Tolin, PI of the global theme on viruses. Four invited speakers from Australia, Guatemala, and USA presented overviews of the principles of vector and virus disease management and emergence of invasive thrips. Case studies showcasing successes achieved by IPM CRSP with whitefly- and aphid-transmitted viruses were presented by Naidu Rayapati, Sue Tolin and Bob Gilbertson. Rayapati leveraged funds (approximately $5,000) from IPM Symposium organizers for travel, registration and accommodation for two invited speakers from Australia and Guatemala. A total of about thirty people attended the session.

Collaborative Assessment and Management of Insect-Transmitted Viruses

Sue Tolin, Virginia Tech

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 using published literature and on-line resources in plant virology. Data were converted by Y. Xia to a searchable format and a link was placed on the IT website. The data set had been constructed in an Excel spreadsheet and contains information, for each crop, on names, taxonomy, and properties of each virus, diagnostic methods, host range, symptoms, insect vectors and other transmission characteristics such as seed and mechanical and geographic distribution. Other data fields for each virus are genome type, size, and sequence(s); coat protein size(s); and serological diagnostic test availability. A second data set is being populated of viruses identified over time in each of the host countries. The number of viruses is increasing as diagnostic capabilities improve in each of the host countries, and identifications are confirmed through this project, collaborating global theme and regional projects.

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. US 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 expertise and facilities to conduct virus diagnosis.

To substantiate the perceived constraints and to better understand in-country capabilities and needs, a survey instrument (in English, French and Spanish) was prepared by graduate student Chang in the Tolin lab to collect information from collaborators within the IPM CRSP host countries and attendees at IPDN workshops sponsored by the Diagnostics Global Theme. Several criteria, including diagnostic capabilities, personnel, infrastructure, equipment, and funding, were included. Of the 14 surveys collected of 20 disseminated, only ten reported performing virus diagnostics. Serology and biological assays using indicator hosts were the primary virus diagnostic methods used. Very few clinics were capable of performing molecular assays due in part to funding, lack of needed equipment, and trained personnel. Those labs capable of performing virus diagnostics were either privately owned or academically affiliated. All government affiliated clinics, and one academically affiliated clinic, did not perform molecular diagnosis of viruses even though some have access to thermocyclers and imagers. Clients varied depending on the affiliation of the lab. Private clinics received a majority of their samples from seed companies and other large corporate entities. Academically affiliated clinics also dealt with companies as well as with researchers and extension agents. Government affiliated clinics received a majority of their samples from large and small farmers and extension agents. Of the samples submitted, more than 50% of tests for virus diseases were on three main crops – tomatoes, peppers and potatoes. Constraints included funding, equipment, facilities and knowledge of personnel. The information gathered in this survey can help diagnostic clinics in developing countries to make international donor agencies aware of their deficiencies and to direct assistance where it is most needed.

In Guatemala, the Univ. del Valle de Guatemala (UVG) group, led by M. Palmeiri, continues to train students and professionals in techniques such as nucleic acid extraction and PCR with degenerate and specific primers, as well as training in RT-PCR to detect RNA viruses and viroids. Two new technicians in the UVG group, Francisco Valencia and Claudia Toledo, a MSc. in Entomology, to support research in Guatemala. In September 2009, Palmeiri and others in her group participated in training with Dr. Marco Arevalo, Central American coordinator for the Global Theme on Diagnostics, IPDN. Individuals participating included Claudia Toledo, supervisor for the technical aspects of the UVG laboratory, and Mónica Orozco, in charge of the quality of the work done. Palmeiri presented a talk about different viruses in Guatemala. Lectures treated techniques; however, no laboratory was included. The main purpose of this event was to interchange experiences in the work we are doing in Guatemala and to learn who is doing what, and who has the diagnostic capabilities. Additional training for M. Palmeiri and for Thomas Peňa on detection of tospoviruses and thrips was provided through workshops at Washington State University in Naidu's lab, coordinator of the Global Theme on Thrips-transmitted Viruses.

In Honduras FHIA has used ELISA kits in their laboratory extensively in previous years. The materials were obtained from US-based suppliers (Agdia, Sigma, etc.) and included kits/reagents for detection of viruses in the genera Cucumovirus, Tobamovirus, Potyvirus and Tospovirus. FHIA ordered ELISA kits in April 2008 for in-country analyses of several viruses. They have often experienced local delays in the ordering process, resulting delays in receiving orders by six months or more, which precluded performing any local analyses during the intended growing season. Zamorano University labs also have the capacity to conduct PCR and ELISA, and established an agreement with Agdia, Inc. in the USA to tested samples of tomato and pepper plants for a number of viruses. Additional TBIA training in Honduras is planned to facilitate use of this method in addition to ELISA kits.

A new diagnostic laboratory in Dominican Republic at IDIAF CENTA for T. Martinez became operational. Assistance in selecting items of equipment and supplies, organizational aspects of the joint labs, and general advice were provided by S. Tolin (Virginia Tech) and M. Deom (U Georgia). The aphid-transmitted *Tobacco etch potyvirus* (TEV) and *Cucumber mosaic virus* (CMV) were identified by ELISA, and immunostrips were used for quick CMV detection. Tolin and Martinez utilized tissue blot immunoassays in the CENTA laboratory and in a week-long visit to Virginia Tech where additional training was give to the host country scientist. In Jamaica, the Univ. West Indies labs have full PCR as well as nucleotide sequencing capability, and have completed work on molecular diversity of TEV. Sequence comparison suggests that some of the isolates serologically positive for TEV may actually be a different virus. Training is still planned for a Dominican Republic scientist to improve her diagnostic skills for begomoviruses by visiting the U. del Valle in Guatemala.

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 on-going 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. Tomato, pepper and cassava samples were collected from the three different agroecological zones of Burkina Faso - Sudan savannah (central part of the country), North Guinean savannah (southern), and the Sahel for virus identification. These were analyzed by collaborator M. Koutou during his training at the Uppsala Biocenter at SLU (the Swedish University of Agricultural Sciences) in Sweden, while on leave from INERA. Samples from tomato, pepper and cassava were subjected to PCR amplification using universal begomovirus primers. Primers for either the core coat protein gene or the full-length genome were used to amplify by PCR and RCA methods, and amplicons were cloned into pGEMT or pJET1.2 blunt end vectors. A large number of resulting clones were sent to collaborator J. Brown (University of Arizona) for sequencing and analysis of extent of diversity. Twenty cloned plasmids of different samples showed the presence of three different species on tomato, one on pepper, and two on cassava. GenBank searches identified three different begomovirus species in tomato (*Tomato yellow leaf curl Mali virus* (TYLCMLV), *Tomato leaf curl Mali virus* (ToLCMLV) and *Pepper yellow vein Mali virus* (PepYVMV)), which was the only species in identified in pepper. The complete full-length sequences confirmed the presence of TYLCMLV and ToLCMLV and some cases of mixed infection of both species. These sequences constitute the first identification of begomoviruses in tomato from Burkina Faso. The complete sequence of the third species (PepYVMV), which was previously identified using CP sequence, will be obtained and compared to known sequences.

In cassava, the two components DNA-A and DNA-B of ACMV as well as DNA-B of *East African cassava mosaic virus* (EACMV) were also identified. Infectivity of the identified species (RCA products, extracted total DNA components were used to bombard *Nicotiana benthamiana* plants. If RCA products are shown to infect plants, infectious clones will be produced and used for germplasm screening for resistance.

b. Appraisal of begomoviruses and whitefly vectors in Cameroon

Based on the complete genome sequencing and sequence analyses, two isolates of a putative new begomovirus have been obtained associated with Ageratum leaf curl disease from South-western Cameroon. Sequencing and sequence analyses of the core CP gene has also identified putative new begomoviruses from weeds of the genera (i) *Malvastrum* and (ii) *Emilia*. Half the B component of a putatively new bipartite begomovirus has also been sequenced from the weed *Clerodendrum*. Complete genome sequencing and sequence analyses have revealed six tentative new species of alphasatellites from the crops Okra and tomato and the weeds ageratum and malvastrum. In a separate study, the complete genome sequence of *Maize streak virus* (MSV) of the A1 sub type has been obtained associated with maize streak disease (MSD) in the western high lands of Cameroon. Whiteflies samples were collected from crops and weeds and sent to J. Brown (U. Arizona) for biotyping. The Cameroon whiteflies were found to be highly divergent, which can probably be attributed to the range of habitats in Cameroon that vary greatly over very short distances.

c. Etiology of okra leaf curl disease and severe tomato diseases in Mali. The UC-Davis group completed its work on characterization of begomoviruses associated with okra leaf curl disease (OLCD) in Mali. They showed that the disease caused by a complex of at least two 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] CLCuGB). The work has been published in *Journal of Virology*.

In addition, the UC-Davis has established that a severe symptom phenotype in tomato, observed in the field in Mali and other countries in West Africa, is due to a reassortant between *Tomato yellow leaf curl Mali virus* (TYLCMLV), a novel recombinant begomovirus composed of sequences of TYLCV and *Hollyhock leaf crumple virus*, and the CLCuGB. Thus, while TYLCMLV does not infect okra, it can form an infectious reassortant with the okra betasatellite and cause more severe symptoms in tomato than are caused by TYLCMLV alone. This finding helps explain some of the diversity of disease symptoms in tomato in the field, and reveals a connection between begomovirus complexes infecting tomato and okra. The latter phenomenon is clearly mediated by the polyphagous nature of the whitefly vector of these begomoviruses. This work has been published in *Molecular Plant Pathology*.

d. Whiteflies in East and 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. Sampling from tomato in two of the three ecological regions of Burkino Faso indicated that *Bemisia tabaci* is a predominant whitefly species. DNA sequencing of the PCR products suggests they are members of the large North Africa/Middle East/Mediterranean clade, which are typically polyphagous populations. Another collection from areas that included the Sahel confirms the preliminary results and indicates the predominance of biotype Q, the Mediterranean clade, in these regions. All the whitefly samples collected over the two last years showed high similarity with North Africa-Mediterranean-Middle Eastern group, suggesting that this whitefly vector is likely to spread begomoviruses among different crops and weed hosts. Collaborations were established to conduct similar analyses of whiteflies collected in Mali and Senegal by the West African Regional IPM CRSP project.

The collaborative research of J. Legg (IITA) and J. Brown, with leveraged funding from Gates Foundation, has enabled enhanced molecular analysis of whiteflies to address the hypothesis that the introduction of an invasive, highly fecund vector haplotype from western Africa was a major driving factor behind the cassava mosaic pandemic in Eastern and Central Africa. About 80-100% yield loss occurs when the 'new' whitefly colonizes cassava, and a mixture of several begomoviruses also infect the plants, implicating synergy between the ' newly emerged' recombinant virus, EACMV-Ug, and/or mixed ACMV-EACMV infection, and the whitefly vector. The recombinant EACMV-Ug is not more virulent than the pre-epidemic, endemic begomovirus, EACMV. Although these observations can explain extreme symptom severity, they do not explain the basis for the emergence of the recombinant virus or unprecedented whitefly levels in cassava. Maternal haplotyping by Mt COI PCR/DNA sequencing has been the basis for biotyping samples across six countries; however this technique did not detect nuclear hybrids. New and more informative whitefly nuclear genome biotyping has been developed by them using microsatellite (STR) analysis to enable analysis of populations to find putative hybrid and non-hybrid native *B. tabaci* in cassava. Population genetics patterns/interactions between invasive and local genotypes based on STR analysis is in progress.

Application of diagnostics to viruses and vectors in Central America and the Caribbean vegetable systems

Confirmation of *Tomato yellow leaf curl virus* in Guatemala. Scientists from UC-Davis and Univ. del Valle detected *Tomato yellow leaf curl virus*-Israel (TYLCV-IL) in samples of tomato with yellow leaf curl symptoms collected in 2007 from Salamá and Sanarate, Guatemala. They collaborated with colleagues at Seminis Seed Co. to test additional samples of tomato and peppers with begomovirus-like symptoms that had been collected in 2006 and 2007 from the Salama Valley. Sequence analyses of cloned PCR-amplified fragments revealed that 3 of 44 and 16 of 118 tomato samples collected in 2006 and 2007, respectively, and 9 of 106 samples from peppers, were positive for TYLCV based on PCR-amplified sequences having >97% identity with sequences of TYLCV-IL. This further confirms that TYLCV has been introduced into Guatemala. The presence of this virus needs to be considered in the development of IPM strategies for management of begomovirus diseases in Guatemala. A disease note on this finding was submitted to *Plant Disease* and has been accepted pending the determination of the complete sequence of an isolate of TYLCV from Guatemala.

Association of other begomoviruses with disease symptoms in tomato in Guatemala. Although there have been as many as eight different begomoviruses associated with virus disease symptoms in tomato in Guatemala, one of the dominant players in this complex is *Tomato severe leaf curl virus* (ToSLCV), as it is consistently detected in PCR analyses of tomatoes with a wide range of virus-like symptoms. Another commonly detected virus is *Tomato mosaic Havana virus* (ToMHV). Furthermore, while the detection of the DNA-A component of ToSLCV is common, a cognate ToSLCV DNA-B component has yet to be detected in samples from Guatemala or elsewhere. Thus, to clarify the role of these viruses in causing the symptoms observed in tomatoes in Guatemala, the Gilbertson lab (UC-Davis) generated full-length clones of the DNA-A component of an isolate of ToSLCV and the

DNA-A and DNA-B components of an isolate of ToMHV. These clones were partially sequenced and confirmed to be ToSLCV DNA-A and ToMHV DNA-A and DNA-B, and were then inserted into binary vectors and agroinoculated into tomato plants. Preliminary results indicate that the ToMHV DNA-A and DNA-B induce moderately stunted and distorted growth and leaf curling, purple vein and yellowing. The ToMHV DNA-A alone was not infectious. When the ToSLCV DNA-A was co-inoculated with ToMHV DNA-A and DNA-B the symptoms induced in tomato were severe stunting and distorted growth and strong leaf curling, purpling and yellow; these symptoms were much more severe than those induced by ToMHV DNA-A and DNA-B. Unexpectedly, the ToSLCV DNA-A alone was infectious and caused mild stunting and distorted growth and leaf curling. This was quite unexpected as the DNA-A components of bipartite begomoviruses are typically not able to induce disease symptoms in the absence of a DNA-B component. However, this may explain why ToSLCV has become such a predominant part of the tomato begomovirus complex in Guatemala. We are conducting additional experiments to confirm this finding.

Characterization of an RNA virus associated with the chocolate spot disease of tomato in Guatemala. The UC-Davis group performed molecular characterization of the virus causing chocolate spot disease in Guatemala. A manuscript describing the characterization of the chocolate spot virus as a new species (proposed name: tomato chocolate spot virus) of torradovirus (the new genus of picorna-like viruses associated with necrosis diseases of tomato) was submitted to Archives of Virology and accepted pending revision. Publication is expected in 2009. Sequence analysis of these RNAs has shown that the genome of the Guatemala virus is similar to, but distinct from, those recently described for *Tomato apex necrosis virus*, *Tomato torrado virus* and *Tomato marchitez virus*; these are new picorna-like viruses that induce necrosis symptoms in tomato. The virus can be detected by PCR and by immunological methods, useful tools for understanding the ecology and biology of this new virus and for developing management strategies.

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. This activity was divided in three main parts, (i) the study of biotypes of whiteflies in Guatemala, (ii) the study of the presence of begomoviruses in Baja Verapaz (Salamá) and Santa Rosa (whitefly monitoring) and finally, (iii) the study of specific begomoviruses in Baja Verapaz (Salamá) and Santa Rosa.

Samples were collected in different regions of the country. In the western (Oriental) region samples were from Zacapa, Santa Rosa, Jutiapa, Jalapa, Chiquimula, and El Progreso. In the central region samples were from Guatemala and Baja Verapaz, in the northern region Petén, and in the southern region, Retalhuleu and southern Quezaltenango. For all the samples, data were taken on altitude, GPS coordinates, name of the plantation, and host plant 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 and at least 5 samples in each category. Samples of whiteflies were collected, classified to species, sexed, DNA extracted using Frolich *et al.* protocol and 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 297 (104 samples from 2006, 92 from 2007, and 101 from 2008) sequenced with the help of the Brown lab at U. Arizona. Arnoldo Font visited the Brown lab to learn techniques and bioinformatic tools for analyzing sequences obtained from the whiteflies. Results show that all whiteflies from Guatemala are from the New World. Biotype B was not found this sampling, one cause could be that melon infected whiteflies were not present. In Figure 1, it can be seen that there are two clades, A and B. The B clade branches into B1 and B2 clades. B1 includes the biotype G5 and the clade B2 includes biotype G6. In the clade A the principally biotype is G1. Clade A subdivides A1 and A2. A2 includes biotypes G4.1 and G4.2 and clade A1 subdivides in a.1.1 and a.1.2. Clade a.1.1 includes biotypes G2 and G3. G2 is found principally in the Northern and Central region. G3 otherwise is found in the Southern and Oriental region. Clade a.1.2 includes principally biotype G1 and is found in the oriental, southern, northern and central regions.

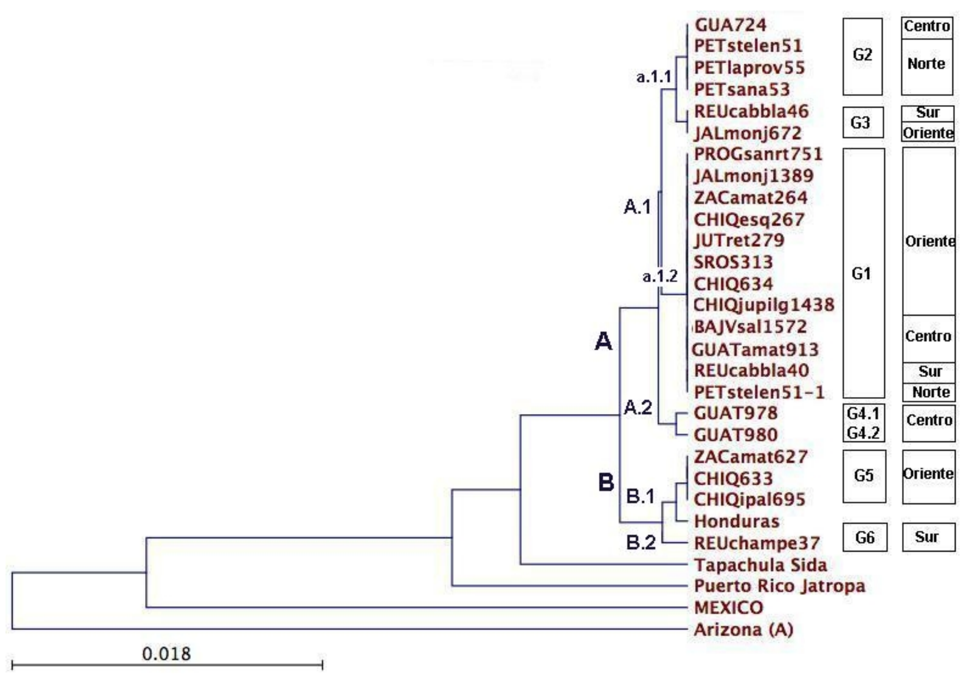


Figure 1: Phylogenetic analysis of cytochrome oxidase gene (COI) of whiteflies sampled in Guatemala from 2006-2008.

Mapping the location of the races showed a relationship to altitude of the collection (Fig. 2). Biotype G1 is present in all regions. G2 is present in the center of Guatemala but principally in the northern region. G3 is more prevalent in the southern region but can also be present in the oriental region. G4 is only in the central region, G5 in the oriental and G6 in the southern region. The biotypes according to altitudes show that no *B. tabaci* was found higher than 2000 m and that G4 is typical of high altitudes (1000 m and 2000 m), even though we can find G1,G2 and G3 but less frequently. G5 is more prevalent in altitudes between 500 and 1000 m SNM as well as G1. G3 is found more frequently between 0-100 m, but G6 is more frequent at that altitude. G2 is more frequently present at altitudes between 100 – 250 m. G1, G3 and G5 also are found between 250-500 m but there is no difference in frequency.

Analysis of biotype relative to host on which samples were taken show G1, G2 and G3 as polyphagus, because they have predilection for more than one crop. G1 and G2 present predilection for tomato (35.3% for G1 and 53.8% for G2) and pepper (42.1% for G1, 46.2% for G2), whereas G3 was collected in papaya (51.7%) and in tobacco (31%). The rest of the biotypes were found only in one crop. G4.1 was collected only on Chile pepper, G4.2 and G5 only on tomato, and G6 only on sandia. The association between the biotype and the crop was statistically significant ($P < 0.05$), establishing that there is an association among them. This association is limited by the geographical area in which the crop grows. The area will have certain crops but if you transfer that crop to another area, the crops are not going to be the same. The whitefly that is accustomed to a certain crop will have to adapt to another crop if doesn't find the one to which is well adapted. G1 and G3 are good examples of this kind of association. In addition, relationships were found between biotypes and time of the year relative to the rainy season.

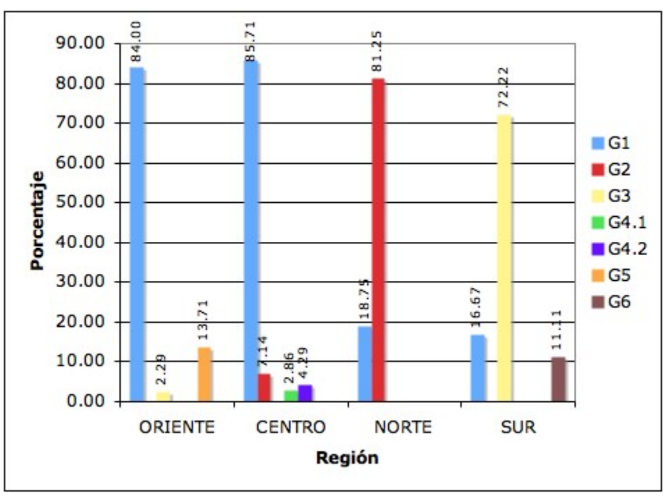


Figure 2: Biotypes of *Bemisia tabaci* per region in Guatemala in percentage from 2006 to 2008

b. Detection of viruses in Honduras

In Year 4 five main sample collections were made and samples were analyzed at FHIA, Zamorano, Taiwan, or in the USA. Results follow.

Collection 1. Samples were collected and analyzed between February/20/2009 and May/10/2009, focused on seven "Departamentos" (equivalent to states) in which vegetables are grown and in which characterization of virus disease has not been previously done or information is scant, namely: Copán (26 samples), Lempira (24), Ocotepeque (21), Choluteca (15), Santa Bárbara (2), Cortés (1) and Intibucá (1); a total 90 samples were obtained from symptomatic plants. Crops represented were tomato (30 samples), Jalapeño pepper (19), bell pepper (14), watermelon (9), potato (4), melon (1), tobacco (2), naranjilla (1), hot pepper (1), "chayote" (1) and weeds (8). The samples were tested locally with imported Agdia ELISA kits for ToMV, PRSV, CMV, TMV, TSWV, PepMoV and a general Potyvirus test kit. In addition, they were all tested for begomovirus using PCR. Findings included confirmation of widespread occurrence of PRSV Potyvirus (26.7% of the samples) followed by TMV (11.1 %), ToMV (3.3 %) and CMV (2.2 %); TSWV and PepMoV were not detected. Begomovirus were detected just once, in a potato sample. Though very low incidence, this is not usual for potatoes are grown in altitudes in which whiteflies normally do not constitute a problem.

Collection 2 and demonstration of tissue blot immunoassay technology for detection of RNA viruses. On May 25- 29 S. Tolin visited Honduras where, together with the project collaborators of Zamorano and FHIA, she held coordination meetings, surveyed field and greenhouse crops in the Comayagua valley, and demonstrated the use of nitrocellulose membranes for leaf tissue blotting and immune-detection of RNA viruses. The most relevant result of this trip was the first report in Honduras of occurrence of "Pepper mild mottle virus" disease (PMMoV), a tobamovirus that was detected in five samples of colored bell pepper grown by "Cultivos del Atlántico" in greenhouses for the export market. Although collected samples were symptomatic, results were mostly negative, including tests by Agdia for 18 viruses of tomato, and 13 viruses of pepper. In pepper, Agdia results confirmed PMMoV in the same samples, and found two samples positive for TSWV.

Collection 3. As part of a collaboration initiated with AVRDC, Wen-Shi Tsai (Assistant Virologist) visited Honduras, visited the Comayagua valley June 2-5, 2009 to observe a trial of AVRDC's hot pepper experimental lines planted in February in FHIA's CEDEH. He performed an assessment of the field reactions to viruses and collected samples from the trial and from other crops in the valley. Around 50 samples were taken back to Taiwan for their analysis.

Confirmation was obtained for the presence of five begomoviruses in Honduras, through the activities of AVRDC-Taiwan. These viruses had been suspected, but not yet demonstrated. In November 2007 and June 2009, Tsai visited the Comayagua Valley to observe the variety trial of pepper from AVRDC. From 39 samples collected in 2007, 18 (6 chili pepper, 4 sweet pepper, and 8 tomatoes) were sent to AVRDC for analysis. Using the primer pair- PAR1c715H / PAL1v1978B, the 1.5 kb viral DNA-A fragments (including the 5' terminal of C1, the intergenic region and the 5' terminal of coat protein gene) were amplified by PCR. Sequencing to determine their exact identities was completed. In tomato, five begomoviruses, namely *Pepper golden mosaic virus* (PepGMV), *Pepper huasteco yellow vein virus* (PHYVV), *Tomato golden mottle virus* (ToGMV), *Tomato mosaic Havana virus* (ToMHV) and *Tomato severe leaf curl virus* (ToSLCV). ToSLCV was in 5 samples, co-infected with ToGMV in two and with ToMNV in one. Two tomato samples were infected with ToMHV alone, and one was doubly infected with PepGMV and PHYVV. In pepper, all 10 samples were infected with PepGMV, with one chili also having ToMHV. In 2009, 23 samples (19 tomato and 14 chili pepper) were collected and sent to AVRDC for DNA amplification using the same primers and sequencing. In tomato, 15 had ToSLCV alone, and 4 were doubly infected with ToSLCV and ToMHV. In 2009 pepper samples from Comayagua, PepGMV was identified in 9 samples from four locations in the Comayagua Valley. ToMHV was identified in four samples, and ToSLCV in one, all from the FHIA station in Comayagua.

The M. M. Roca laboratory at Zamorano conducts virus diagnosis, and has forged strong relationships with private companies specializing in this area, mainly Agdia and Envirologix in the USA. 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 are being 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. Of samples of pepper and tomato collected during Tolin's March 2009 visit, 29 were shipped directly to the research division of Agdia, who tested them for all viruses in their catalogs known to infect pepper or tomato, respectively. Only PMMoV and TSWV were detected. Those samples positive for PMMoV had been positive by TBIA. It is still possible that there are strain differences, or that there are new viruses not included in banks of antiserum prepared largely from viruses isolated in temperate regions. Alternatively, the virus-like symptoms may all be caused by begomoviruses recently detected by AVRDC in Honduran samples. The reason why all PCR tests conducted at Zamorano or at FHIA for these viruses have thus far yielded no positives, is not know, but needs further examination.

Collection 4. In Honduras, potatoes are an important staple crop that for different reasons has not received technological support for many years. The status of virus diseases is practically unknown, although the claim is that viruses are seriously affecting the local crops. To elucidate the situation, FHIA invited the local office of FAO and the USAID-funded project RED to finance the conduct of a survey of viral diseases of potato in the main growing areas of the country. Support was obtained from them in the amount of US$ 11,000 ($ 6,000 from RED and $ 5,000 from FAO) to pay for the analyses of 100 samples to be submitted to Agdia (Elkhart, Indiana). Agdia's potato screen lists 31 viruses and 1 viroid. It was decided to test the samples for 17 viruses and 1 viroid which, based on pertinent literature reviewed, could be the most likely pathogens occurring locally. An initial batch of 40 samples taken at the end of the dry season were sent to Agdia in early June. Results showed that only three samples tested positive to PVY and the general Potyvirus test, and another four tested positive to begomovirus. These results seemed to negate the claim that virus diseases are a major problem in potatoes, although it appears obvious that a pathogen is afflicting the crops since all sampled plants were showing abnormal symptoms reminiscent of virus diseases.

Collection 5 and use of membrane-based technologies for detection of DNA of plant pathogens

From June 18 thru 22, 2009, J. Brown visited Honduras, during which time she traveled with J. C. Melgar to the Western region of Honduras to observe potato crops in which symptoms reminiscent of viral disease have occurred frequently the last four years. Some 90 samples of symptomatic leaf tissue were collected into glycerol and/or blotted onto nylon membranes. In addition, about 100 specimens of the potato psyllid, a potential vector, were collected. Samples were taken to Brown's lab in Arizona for analysis using a PCR assay she had recently developed to detect a new bacterial pathogen, *Candidatus* Liberibacter, in tomato and potato. DNA isolated from glycerol-preserved leaves was subjected to PCR and products were transferred to a nylon membrane and tested with a *Ca*. Liberibacter probe to determine if detection could be enhanced, and also to confirm that PCR products were of *Ca*. Liberibacter origin. The results obtained to date show that of 34 symptomatic leaf samples placed in glycerol, 20 tested positive to the bacterium in 2 of 3, or 3 of 3 tests. Some fresh leaves of the same samples that had been express mailed to Arizona did not survive shipment. This finding confirms a preliminary analyses on local samples performed by Brown, and it may explain why previous analyses of symptomatic potato detected no viruses. In the USA and other areas, this pathogen has been confirmed as the cause of the disease known as "Zebra chip". These findings have serious implications for the local potato growers and the agri-industry, and should have to a priority in future collaborative research and technology transfer work.

c. Detection and assessment of viruses in pepper and tomato in the Dominican Republic

During the year 2007-2008, the IDIAF group led by T. Martinez worked on diagnosis of TEV and CMV on protected crops as well as in open fields. Protected crops (large greenhouses) are increasing in the production of pepper 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: TSWV on pepper and tomato in two facilities, CMV on pepper in one facility, and PMMoV on pepper. Additional work is planned on viruses in plants grown in protected greenhouses.

The identity and distribution of aphid-transmitted viruses infecting pepper in nine localities in Paya, Bani, and Ocoa was assessed by Martinez and her student assistants. By ELISA using Agdia kits for TEV and Agdia immunostrips for CMV, it was shown that TEV is the predominant virus in pepper. Of 905 samples, 641(71%) were positive TEV, and 234/905 (29%) positive for both CMV and TEV.

Samples were also collected from farmer fields at three localities (Mayita, Nizao and La Auyamas) and from experimental plots at Sabana Larga, Ocoa, at the Experimental Station. These were taken to IDIAF to blot onto nitrocellulose membranes then taken to Virginia Tech for testing by tissue blot immunoassay (TBIA) for CMV and TEV during the week-long visit of Martinez for training in TBIA. Ninety-two were positive to TEV, 18 positive for CMV, and 8 were infected with both viruses. The initial attempts to obtain nucleotide sequence information on these viruses was not successful, using a method developed by P. Chang in Tolin's lab to reverse transcribe viral RNA directly from TBIA membranes, and conduct PCR with primers specific for CMV or TEV. However, from collections made during Tolin's March visit that were positive to by TBIA to CMV, coat protein sequences were obtained from PCR amplicons and found to be members of sub-group I of CMV. Materials were provided to Martinez for further TBIA and molecular testing of these viruses in Dominican Republic, which will occur in the next phase of the IPM CRSP.

d. Detection and diversity of aphid-transmitted viruses in Jamaica
The U. West Indies (W. McLaughlin) is well-equipped for molecular detection of viruses, and has acquired an ABI nucleotide sequencer, thus has the capability to sequence PCR amplified and/or cloned viral nucleic acids. Effort has focused on *Tobacco etch virus* (TEV) from hot pepper, obtaining sequences from a number of isolates from infected Scotch Bonnet pepper. In Year 4 funding was obtained to examination additional TEV isolates. Ten symptomatic pepper samples were collected from each of the following locations; Bodles Agricultural Research Station, St. Catherine; Ebony Park HEART Academy, Clarendon; CARDI and UWI, Botany Gardens, Kingston, and total RNA extracted. The coat protein (CP) coding region of the viral genome was amplified, cloned, and the clones sequenced and analyzed to ascertain the genetic diversity of the virus infecting Scotch Bonnet pepper. Multiple alignments of the deduced amino acid residues revealed two highly conserved DAG motifs within the N-terminus of the CP, typical of highly aphid transmissible (HAT) TEV. The nucleotide and amino acid sequence similarities varied from 85 to 100%, and 67 to 100%, respectively. Nucleotide and amino acid sequence similarity indices, and phylogenetic analyses unequivocally confirmed a single species of TEV infecting peppers in Jamaica. These data can be used in molecular ecology studies of strain distribution, transmissibility, and severity in peppers. A manuscript is under review.

The Ministry of Agriculture personnel collected samples potentially infected with CMV, providing tissue blots on membranes to P. Chang for a study of the diversity of CMV. However, none of the samples were positive for CMV in the areas where collections were made from cucurbits.

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 3 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 UC-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. This is accomplished by testing whiteflies, collected at monthly intervals and sent to UC Davis in ethanol by our DO collaborators, by PCR with TYLCV-specific primers.

The host free period of 2008 (June-August) reduced the levels of TYLCV detected in whiteflies, indicating that this strategy was effective at reducing virus inoculum levels. For the 2008-2009 growing season

(September 2008-May 2009), a low level of virus was detected in whiteflies collected from various locations in the North and South by the end of September (using the more sensitive PCR/Southern blot test), indicating that the virus was starting to build-up more rapidly than in previous years. However, TYLCV was not detected in whiteflies collected at the end of October. This was attributed, in part, to low overall whitefly populations. However, by the end of November, whitefly populations had increased and most of the samples were positive for TYLCV. Tomato yellow leaf curl symptoms also were beginning to appear in the field, consistent with detection of the virus in whiteflies. TYLCV was detected in almost all whitefly samples from the end of December and January, with the exception of one isolated production area (Juancho, Enriquillo). By the end of February, as fields in the North were being harvested, virus was detected in less than half of the whitefly samples (2/6), whereas all of the whiteflies from the South (Azua), where the season was later, were strongly positive. Whiteflies collected from Juancho at the end of February were weakly positive. By the end of March and April, TYLCV continued to be detected in most whitefly samples from the North and South and those from Juancho were now strongly positive. Consistent with this, virus symptoms were observed in the Juancho fields. By the end of May, TYLCV was detected in less than half of the whiteflies from the North and South, where the season was ending. In contrast, in Juancho, where the season was later, a high level of TYLCV was detected in the whiteflies. The 2009 host-free period was implemented in June and sanitation efforts resulted in the removal of old infected plants harvested fields. Very little TYLCV was detected in whiteflies collected at the end of June and July, and no TYLCV was detected in whiteflies collected at the end of August or September (based on PCR tests). Together, these results indicate the continued success of the host-free period in reducing TYLCV inoculum levels from very high at the end of the growing season to undetectable by the end of the host free period. This information is important to assure growers that they can still plant high yielding TYLCV susceptible cultivars early in the season. However, our results show that, despite the host-free period, TYLCV eventually builds up to high levels and that later plantings should use TYLCV resistant varieties. These data are also used by the government as evidence to continue to enforce the host-free period. Moreover, growers seem to recognize the importance of this program, and it has become a standard practice in areas of the Dominican Republic.

b. Aphid-transmitted virus ecology and disease management in Dominican Republic

Because of the high incidence of aphid-transmitted viruses, host country scientist T. Martinez visited Jamaica in September 2007 to observe research approaches used there to design IPM packages. One experiment was conducted in 2008 and a second one in 2009, at the Ocoa Valley, Campo Experimental del Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF). The experiment had the objective of examining TEV epidemiology, and rate of disease development during the lifetime of the crop. Pepper (*Capsicum annuum*) seedlings were grown under protected conditions to assure virus-free transplants. Three plots of 880 plants per plot, a total of 2,640 plants, were established. Nine plate traps (green) were used to catch insects, and were painted to resemble mosaic pattern with yellow paint (at the suggestion of S. MacDonald, Jamaica). The traps contained water, glycerin and soap, and trapped insects were collected weekly. Aphids collected during the experiment were: *Aphis craccivora* - 34%, *Myzus persicae -10%, Aphis gossypii - 6%,* all known to be efficient vectors of TEV. Plants began showing symptoms 15-21 days after transplanting. Only symptoms attributed to TEV were recognizable, as it seemed to mask CMV symptoms as plants infected with both viruses could not be distinguished from those positive for only TEV. Virus incidence reached 40% by flowering, and 95% by the end of the experiment. Yields could not be taken because of insect damage that cause fruit drop. Experiments are in progress to assess aphid behaviour outside of pepper, and to observe whether tomato, hot pepper, and the cucurbit Auyama would become naturally infected with CMV and TEV. The most prevalent insect after planting in August 2009 was whitefly on tomato.

A new grower of pepper for exportation was located in Las Caobas, Ocoa, with a new planting next to an old field showing symptoms. Samples taken from the field at 39 days after transplanting were positive for CMV, but could not tested for TEV because supplies were not available. This field will be used as an example for growers of a practice that will result in high levels of early infection with viruses.

c. Implementation of a host-free period IPM strategy for viruses in the Salamá Valley of Guatemala.

Based on successful approaches in other locations, the goals in Guatemala are to establish a host-free period as an IPM strategy to manage viruses, based on successful approaches in other locations. The research has been done by M. Palmeiri and her associates and students of the U. del Valle, and by R. Gilbertson, using leveraged funding from farmer's groups and the Government of Guatemala. J. Brown has assisted with whitefly speciation and identifications.

Based upon our findings to date, we are recommending the following IPM practices for whitefly-transmitted begomoviruses infecting tomatoes and peppers. Although it has been agreed that the best time for the host-free period in Salama is May-July, this program has not yet been widely adopted.

1) a 2 month host (pepper/tomato)-free period

2) continued evaluation and adoption of new cultivars (e.g., with TMV and begomovirus resistance)

3) selective use of insecticides (e.g., neonicotinoids and/or insect growth regulators)

4) biological control of whiteflies

5) use of row covers to keep whiteflies and other insect pests off plants at a young age

6) extensive sanitation

<u>Research Methods</u>: Two visits (Salamá and Santa Rosa) were made: once after the rainy season (December 2008 – February 2009) and once in the dry season (April 2009 – May 2009). In each valley we visited 3-5 fields located in the 4 cardinal points and the center. Each field corresponds to a sample collection point where approximately 100 whitefly adults were collected and transported to the laboratory in 80% ethanol. Once in the laboratory the whiteflies were classified by gender (male/female) and species (*Bemisia tabaci, Trialeurodes vaporariorum* among others). The female *B. tabaci* were used for PCR detection of begomoviral load. For each sample

collection point, PCR's are performed on 10 individual female *B. tabac.* The test is well optimized to detect the viral load of a single whitefly. Two weeks after the sampling, the growers get a report including the whitefly distribution by gender and species and the begomoviral load in *B. tabaci*. The 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, in each of the two species studied. The values generated for each month were graphed to establish temporal epidemiology of begomovirus in whitefly vectors in the Salamá and Santa Rosa valleys in the two climatic seasons.

In the year between October 2008 and September 2009, we did not make monthly visits to Salamá and Santa Rosa valleys. Instead, we visited each valley twice: once after the rainy season (December 2008 – February 2009) and once in the dry season (April 2009 – May 2009). Visits were arranged in this manner because in order to confirm that the data collected from the monthly visits during the past three years could predict the begomoviral load during the different climatic seasons. Besides, it is known that the growers in these valleys respect the host-free period calendar, so the begomoviral load should behave according to this calendar. Generic primers were used initially, but specific primers are now used for *Pepper Huasteco yellow vein virus* (PHYVV), *Pepper golden mosaic virus* (PepGMV), *Tomato mosaic Havanna virus* (ToMHV),*Tomato golden mosaic virus* (ToGMV), *Tomato severe leaf curl virus* (ToSLCV), and *Tomato yellow leaf curl virus* (TYLCV) all having been reported in Guatemala and other countries in Central America.

The percentage of each of the six begomoviruses varied with season and with location. In Salamá after the rainy season (Dec08-Feb09), ToSLCV and ToGMoV were in 56% of the whiteflies tested and TYLCV in 22%, whereas after the dry season (Apr-May 2009) three viruses detected were TYLCV, PHYVV, and ToMHV, each 50% of the whiteflies tested. In Santa Rosa, viruses were not tested after the rainy season and after the dry season, ToSLCV was detected in 100% of the whiteflies tested, with 20% having ToGMoV and 60% ToMHV. These data show a great diversity of begomoviruses in the Salamá Valley, and that TYLCV has become a part of the circulating begomovirus complex in the valley.

In 2008 and 2009, FASAGUA, which is the institution collaborating with the whitefly monitoring, has published an 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 to 15 other valleys.

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 only by applying pesticides, that they must understand disease cycles and factors that affect them. Also they will be aware of different crop possibilities, not only the crop they usually plant. For example, instead of not planting a crop during the two months that are needed for the elimination of Begomovirus in a generation of *B. tabaci*, farmers can still plant a non Begomovirus host.

The data obtained from previous year's monitoring sets the basis for predicting the following year's begomovirus epidemiology, which was confirmed with this year's sampling. Knowing what the relationship is between begomovirus-whitefly throughout the entire year (in every climatic season) has allowed prediction of the most adequate time to break the virus-vector cycle through the establishment of a mandatory host-free period in each valley. Salamá's host free period was established for January and February and June and July 2009, and Santa Rosa's was established for November and December 2008 and October and November 2009.

One of the most important impacts of this work is that Guatemala now has more personnel trained in the techniques to approach the viral problems of the grower in the field. The training-learning cycle does not end because every semester new undergraduate students come to do their training in Palmieri's laboratory. This will help to give better support to growers in the near future.

d. 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 Top Hill and Southfield districts, and in St. Catherine, fields were monitored in Bushy Park and Thetford districts. The activity involving evaluation and transfer IPM packages for whitefly-transmitted viruses in tomatoes in Jamaica and was to be conducted evaluating several tomato varieties bred for resistance to TYLCV. This study would have been superimposed on a baseline study conducted by the Ministry of Agriculture and a private seed company in which different tomato varieties would be assessed for yield and other agronomic characteristics. However, the baseline study was not conducted.

e. Evaluation and technology transfer IPM packages for aphid-transmitted viruses in pepper in Jamaica

IPM packages were evaluated by the Ministry of Agriculture Experimental Station at Bodles, Old Harbour, St. Catherine, Jamaica, designed and managed by collaborators S. McDonald and L. Myers. The experimental design for the study conducted at Bodles was randomized complete blocks, each with the following treatments: straw mulch, a resistant pepper hybrid variety, Scotch bonnet pepper treated with neem formulation, straw mulch with the resistant pepper hybrid variety, straw mulch with Scotch bonnet pepper treated with neem formulation, and a control (Scotch bonnet pepper only). This study was conducted at Bodles. A second study conducted on two private farms in Thetford and in Nightingale Grove Farms in St. Catherine was comprised of randomized complete blocks, each with the following treatments: straw mulch, NanoGro, soil plant growth-promoting bacteria, NanoGro and straw mulch, soil bacteria and straw mulch, and a control (Scotch bonnet pepper only). W. McLaughlin's team (UWI) provided bacterial cultures and technical assistance in inoculating pepper seedlings with soil growth-promoting bacteria and with the collection of data from the two private farms.

Plants in all plots were monitored for incidence of natural infection, via aphid transmission, with *Tobacco etch virus* (TEV) throughout the growing period. Yield and growth data were collected for each treatment. Pepper seedlings were transplanted in fields on private farms on 21 November 2008 and data were collected weekly from 3 December 2008 through 16

April 2009. Pepper seedlings were transplanted at the Bodles Experimental Station on 1 December 2008 and data were collected weekly from 18 December 2008 through 17 April 2009. Results varied with location, as described in the following:

At Nightingale Grove, the first symptomatic plant was observed in the second week of transplanting. Thereafter, infection spread rapidly in each treatment. Over 45% of plants in all treatments showed symptoms within five weeks of transplanting and over 90% of plants in all treatments were infected within eight weeks of transplanting.

At Thetford the first symptomatic plants were observed four weeks after transplanting. Thereafter, infection progressed slowly throughout the field with the greatest number of infected plants being observed in the southern end of the field. There did not appear to be any distinction in the rate of infection among treatments. Fifteen weeks after transplanting, the mean number of infected plants in treatments within the southern-most block, Block 3, was 60%. Mean number of infected plants per treatment in Block 1 and Block 2 were 21% and 2%, respectively. This pattern of spread continued throughout the growing season.

On the Bodles Experimental Station, the first symptomatic plants were observed six weeks after transplanting. Thereafter, infection progressed from these points of infection throughout the field, with the exception of the resistant pepper plants. None of the resistant pepper plants showed symptoms of tobacco etch until after the 16th- week of transplanting. Resistant plants from mulched (2 plants) and non-mulched (3 plants) plots in the third experimental block, and one plant from the non-mulched plot in the first block showed symptoms of infection.

Differences in yield were observed only between treatments with mulch and those without mulch, on both private farms. Plants within mulched plots bore more fruit per pepper tree. There did not appear to be any difference in yield among the other treatments. Generally, the resistant treatment with mulch and the resistant treatment without mulch produced more fruit per plant than the other treatments.

Managing viral diseases in vegetables through resistance to economically important insect-transmitted viruses

a. Identifying vegetable varieties with resistance to prevalent viruses

From web sites of various commercial vegetable seed companies, Deom (U. Georgia) collected information on numerous vegetables 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, was provided to Rivera at FHIA in Honduras, and to Martinez at IDIAF in 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.

b. Response of local varieties of vegetables and AVRDC germplasm to natural infection with viruses in Honduras

A trial was established in Year 4 at CEDEH-FHIA (Comayagua Valley) in 2009 to evaluate the reaction to the locally-present viruses and production performance of *Capsicum* peppers in collaboration with AVRDC. Eleven lines were selected from the lines with begomovirus resistance in Mali (including PY No. 3, 5, 9, 10, 22, 30, 33, 134, 147, 163 and 150). Twenty-five lines (PY No. 1, 2, 4, 7, 8, 15, 18, 24, 27, 34, 39, 45, 108, 112, 119, 127, 130, 151, 168, 169, 175, 178, 208, 209, 210 and 212) that showed resistance in India and/or Thailand were also included. Two pepper lines (PY4 and 12) were selected from the collection of AVRDC - The World Vegetable Center. The seeds were treated with tri-sodium phosphate to destroy any contamination with *Tobacco mosaic virus* and were sown on 3 February 2009. Plants were transplanted to the field on 24 March 2009. Twenty-three plants per line were planted in each replication. Virus symptoms were visually recorded by a simplified rating system: 1= no virus symptom; 2= yellowing; 3= yellowing and leaf curling; 4= yellowing, leaf curling and small leaves; 5= yellowing, leaf curling, small leaf and/or stunting.

All pepper lines, except PY163 showed high virus incidence and severity based on visual rating. The PY163 line showed low virus incidence (33%) and severity rating (1.3). One sample per line with virus disease symptoms from replication 1 was tested for begomovirus infection by PCR using the general primer pair-PAR1c715H / PAL1v1978B, and by ELISA for the presence of 7 RNA viruses: *Cucumber mosaic virus* (CMV), *Chilli veinal mottle virus* (ChiVMV), *Pepper mild mottle virus* (PMMoV), *Pepper veinal mottle virus* (PVMV), *Potato virus Y* (PVY), *Tomato mosaic virus* (ToMV) and *Tomato spotted wilt virus* (TSWV). All samples, except that from line PY15, tested positive for begomovirus, and none tested positive for any of the RNA viruses.

c. Exploring the use of transgenic resistance to viruses

Deom (U. Georgia) and M.M. Roca (Zamorano) are working to complete the "USAID Biosafety Proposal and Reporting Requirements" process, as well as the Honduran Biotechnology and Safety Committee process, for approval for testing transgenic tomato containing resistance to TMV in the field in Honduras, but were unable to finish. Although the transgenic tomato screening for resistance was not yet approved so that testing could begin in Year 4, the seeds are being preserved so that this testing can be done a later date.

d. Induction of resistance by use of biocontrol organisms in Jamaica

Two bacteria, *Bacillus* UWI-3 and *Pseudomonas putida* NCIMB 9571 were tested as single inoculants and in combinations of 1:1, 1:2 and 2:1 for biological control of TEV infecting Scotch Bonnet pepper under greenhouse conditions. Plant growth promoting parameters observed included the ability of the biocontrol isolates to stimulate root elongation, and to increase shoot growth, nutrient uptake, and shoot and root dry weight. Bacterial treatments, either singly or in combinations, also elicited significant reductions in disease severity based on symptom expression. Disease severity ratings were reduced by as much as 93% at four weeks post virus inoculation in plants treated with bacteria. Virus spread and titer were reduced by 72% and 32%, as measured by leaf imprint immunoblot and double antibody sandwich enzyme-linked immunosorbent assays (DAS-ELISA), respectively, in the leaves of the bacterial treated and TEV infected plants, relative to non-treated plants. Reduction in disease severity could be caused by the ability of *Bacillus* UWI-3 and *Pseudomonas putida* NCIMB 9571 to elicit induced systemic resistance (ISR). *Bacillus* UWI-3 and *Pseudomonas putida* NCIMB 9571 were effective alone and were compatible as mixtures, and resulted in significantly greater shoot growth, and shoot and root dry weights, as well as significantly higher phosphorous and potassium shoot levels, over the TEV infected control plants. These bacteria were incorporated into a field experiment by the Ministry of Agriculture designed to develop an IPM package to mitigate losses caused by TEV in hot pepper.

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

Yulu Xia, North Carolina State University

The collaborative program

This global theme collaborates with almost all IPM CRSP programs through:

1. IT and database consulting and by creating two interactive information systems/software tool e.g. GlobalPestInfo and the software applications mentioned above
2. West African Regional IPM CRSP program (lead by VT) on West African Regional IPM Network which emphasizes information about whitefly
3. Southeast Asia IPM CRSP (lead by Clemson) on Southeast Asia IPM Network which emphasizes pest information delivering and sharing
4. IPM CRSP programs in LAC
5. IPM CRSP for Central Asia

This program also collaborates with other international and national programs. It also collaborates with USDA APHIS on pest information sharing in Africa, the Caribbean, and Asia. We work with Bionet on training in using database for sharing information of invasive species.

IPM constraints addressed. This global theme addresses the issues such as information sharing, delivering, and data analysis in IPM research, education, and practices. We are not directly dealing with the issues such as pest management, pesticide use, and biodiversity.

Development of Decision Support Tools (to organize, analyze, communicate and store IPM information)

It has been expanded to include three major tasks: GlobalPestInfo (formerly called "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 developed from or provided by this project will enhance capacity in research, training, education, extension, and IPM practice, help communication of pest information among the regions and HCs, expand reach of IPM data and information. It also improves the quality of policy making by providing sound information and efficient communication channels.

We had two meetings with our collaborators at Virginia Tech early during the period to discuss revision of the information system. A number of changes and updates were made after the meetings.

A series of newly written insect pest management review papers have been added to the website.

Substantial amount of new links and data were added to the Southeast Asia program. This site can link to the pest management web sites in almost all major countries in the region.

In the LAC/Ecuador pest information system, GIS, databases, and Web application projects for visualization and improved understanding and communication of biotic and economic interactions will be developed.

Result from this activity will help communication among scientists, IPM practitioners, growers, and policy makers in regarding pest population dynamics, and the interactions among biological and non-biological factors in regarding agricultural pests and their natural enemies. It will help understanding the factors that impact pest population and control outcome.

Web, database, and GIS/ interactive cartography integration and applications

1. CaribbeanPestWatch (http://www.caribbeanpestwatch.org). Collaborators in Penn State and Jamaica are adding the ground survey data to the system.
2. PestMapper. We intensified work in this software during last several months. This GIS software is ready for using in IPM CRSP community. Details are available at: http://www.pestmapper.org/version1/
3. PestNewsViewer. This is a newly developed software for GIS and other relevant applications. This is a link to an introduction about the software: http://www.pestmapper.org/version2/about.cfm

Hardware and software readiness, Database design and metadata definitions, web browsing, and dynamic web programming

We have been working with Insect Transmitted Viruses Global Theme and LAC Regional Progarm on virus database. We are also working with Ecuador to help to setup a national pest information system.

In collaborating with the ME, this global theme provided and developed information tools for general uses. For example, we developed IPM CRSP Country Activity Map so that user can view the whole IPM CRSP projects on a dynamic map. We also developed IPM CRSP Publication database. Users can search the publications online. To facilitate future collaboration among this community, we developed online IPM CRSP Forum.

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

GlobalPestInfo will use Web Services to seamlessly integrate search functions with both USDA Regional IPM Centers' databases and the IPM CRSP Reporting System

We have collected almost all major global, regional, and U.S. pest management links. Our GlobalPestInfo is a starting point to many international and national pest management information links. Our pest linkage might be one of the most comprehensive sites in the world.

We have more than 200 links to international and national pest management online information sites.

IPM Impact Assessment for the IPM CRSP

George Norton, Virginia Tech

Collaboration with IPM CRSP regional and global themes

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

Budget data were collected this past year to help with assessment of economic impacts in regional programs. A summary report was completed based on previous and new economic impact analyses for the IPM CRSP.

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

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

Collection of data on pest losses by crop and country and analyze potential economic impacts of IPM

Graduate student Jason Beddow at Minnesota continued collection and analysis of new insect and disease data as described in the FY 2008 annual report. Intensive research collaboration on insect and disease modeling and data collection was fostered by visits to IRRI, CIAT, CIMMYT, CSIRO and the University of Queensland, in addition to consultation with the USDA Cereals Disease Lab at the University of Minnesota (among others). Efforts continued from FY08 include additional development and use of the Virtual Georeferenced Elicitation Tool (V-GET) and the CLIMEX/DYMEX modeling platform, both of which were described in more detail in the previous annual report (pp. 134-136). V-GET pest and disease data collection and modeling efforts have expanded to include significant and on-going participation from private industry in addition to IARC collaboration. Beddow has also collaborated on the *HarvestChoice*-led effort in partnership with CSIRO, Australia and various project consultants to enhance the CLIMEX model and software by increasing the available modeling options and enabling multi-year simulation of potential pest and disease suitability. A beta version of this enhancement is presently being evaluated. Among other benefits, these improvements allow for much richer economic analyses of pest and disease risk.

Impacts of IPM in Developing Countries: Evidence from the IPM CRSP

Graduate student Tatjana Hristovska at Virginia Tech conducted impact assessment research to review and summarize results from previous economic impact studies on the IPM CRSP and to present results of new economic assessments of IPM CRSP programs in Albania, Uganda and Ecuador.

The following table (Table 1) summarizes several results from previous IPM CRSP impact studies that were reviewed which used the economic surplus and benefit cost analysis methods.

Table 1: Review and summarization of results from previous economic impact studies to determine the overall impact assessment of the IPM CRSP

Country and Authors	Crop	IPM Practice (s)	Net Benefits
Uganda, Moyo et al, 2007	Peanuts	Virus resistant variety	$36-33 million
Mali, Nouhoheflin, et al, 2008	Tomato	Cultural	$2-12 million
Uganda, Debass, 2000	Beans and maize	Cultural	$36-202 million
Philippines, Mamaril and Norton, 2006	Rice	Insect resistant variety	$136-276 million
India, Mishra, 2003	Eggplant	Insect resistant variety	$279-773 million
Bangladesh, Debass, 2000	Eggplant, cabbage	Cultural practices	$26-29 million
Bangladesh, Rakshit, 2008	Cucurbits	Pheromone traps	$4 million
Ecuador, Baez, 2004	Plantain	Cultural	$59-63 million
Ecuador, Quishpe, 2001	Potatoes	Resistant variety	$50 million
Albania, Daku, 2002	Olives	Cultural	$39-52 million

Table 2: Sensitivity analysis showing a range of benefits

Country	Crop	Treatment	Total
Albania	Tomato	Soil Solarisation	$36-55 million
Ecuador	Plantain	Cultural practices	$4-12 million
Uganda	Tomato	Cultural practices and resistant variety	$1-2.5 million

Additional Economic Surplus Analysis of IPM CRSP Impacts

New economic surplus analyses were conducted for tomatoes in Albania and Uganda and for plantain in Ecuador. The IPM practice of soil solarization used to manage the root know nematode (*Meloidoyne inconita*) was evaluated for Albania, while IPM practices of staking, mulching, minimum pesticides, raised beds, and a virus resistant variety (MT56) were assessed for Uganda. IPM practices evaluated for plantain production were sanitization, fertilization and plantain spacing, cultural control of diseases, and biological control of insects. Sensitivity analysis was conducted, resulting in a range of benefits (Table 2).

Conclusion on Market Level Economic Benefits

Several conclusions can be drawn from the results in tables 1 and 2. First estimated benefits of the IPM practices that were evaluated are high enough to offset the entire cost of the IPM CRSP program even though this set of practices is only a fraction of those generated by the program. Second, the range around the benefits indicates that measurements or estimates associated with key assumptions make as large difference in the final estimated benefits. Third, the plantain example which involved projecting benefits early in the adoption process (table 1) and again later in the adoption process (table 2) illustrates the difficulty of projecting the extent of adoption early in the process.

Other Benefits

Environmental, health, nutritional and poverty reduction benefits were also evaluated. It was determined that most IPM CRSP projects resulted in a reduction of pesticide use which leads to health and environmental benefits. Improved productivity as a result of IPM practices led to changes in prices and consequently consumption. For example, the increased yields resulting from the transfer of eggplant grafting techniques in the Philippines led to an increased consumption of 90 calories per person per day. Similar results were found in Bangladesh as well. Additionally, poverty was reduced in those areas where incomes were increased 0.5 to 5% depending on the size of the area considered.

Preparation of training materials for IPM impact assessment

Training materials in Spanish are complete.

IPM CRSP Management Entity Activities

The Management Entity (ME) at Virginia Tech provides overall guidance in the management of the IPM CRSP. It arranged for a Technical Committee meeting in March 2008 in conjunction with the International IPM Symposium. Four workshops and several posters were presented by the IPM CRSP ME, PIs and host country partners. The IPM CRSP also won several accolades during this year. The International IPM Symposium presented the International IPM Excellence Award to IPM CRSP at its Portland meeting in March 2008. IPM CRSP Bangladesh program of the South Asia project was awarded he Ryutaro Hashimoto Asia-Pacific Forum for Environment and Development (APFED) Silver medal in 2008 and it was also one of the three finalists for the Ashoka Change Makers 24th Collaborative Competition in 2009. The IPM CRSP Central Asia program was a co-recipient of the King Baudouin Award 2008 with ICARDA.

On June 3, 2009 USAID requested an application from Virginia Tech for the renewal of the IPM CRSP for a period of five years from October 1, 2009 to September 30, 2014. The proposal for the renewal was submitted to USAID on June 29, 2009. A request for applications for regional and global theme programs was released on July 6, 2009.

The programs were:

Regional

- Central Asia – Kyrgyzstan, Tajikistan, and Uzbekistan
- East Africa – Kenya, Tanzania, and Uganda
- South Asia – Bangladesh, India, and Nepal
- Southeast Asia – Cambodia, Indonesia, and the Philippines
- Latin America/Caribbean – Dominican Republic, Ecuador, Guatemala, and Honduras

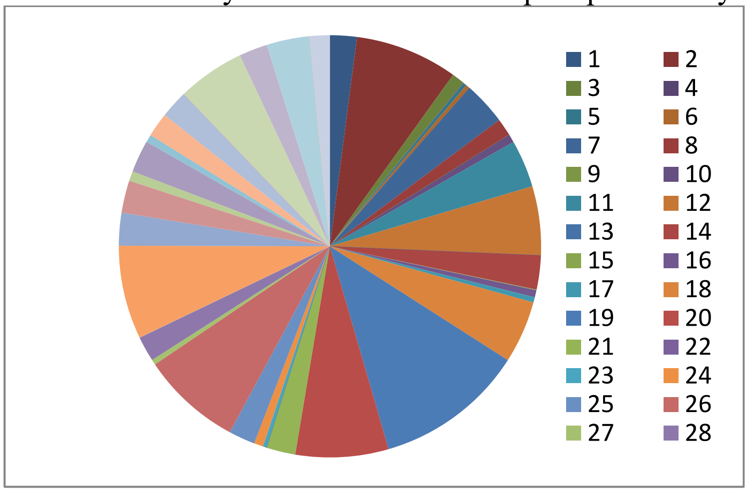
Global

- Plant virus diseases
- Impact assessment
- International pest diagnostic laboratories
- Invasive species program on *Parthenium*
- Gender knowledge and application (issued without competition)

The External Evaluation Panel consisting of Dr. Barry Jacobsen (plant pathologist), Dr. Susan Capalbo (agricultural economist), Dr. Dely Gapasin (entomologist), Dr. Roy Nishimoto (weed scientist) and Dr. Revathi Balakrishnan (gender specialist) reviewed the proposals and provided recommendations.

In FY 2009, Dr. Bruce A. McPheron, Dean of the College of Agricultural Sciences at Pennsylvania State University and Dr. Joseph Culin, Associate Dean of Research and Graduate Studies in the College of Agriculture, Forestry and Life Sciences at Clemson University joined the IPM CRSP Board. Dr. Johnny Wynne, Dean of the College of Agriculture and Life Sciences at North Carolina State University and Dr. Thomas I. Schwedler, Associate Dean for Research in the College of Agriculture, Forestry and Life Sciences at Clemson University left the Board.

Table 1: Summary of IPM CRSP funds spent per country.



1	Albania	23	Kazakhstan
2	Bangladesh	24	Kenya
3	Benin	25	Kyrgysztan
4	Botswana	26	Mali
5	Burkina Faso	27	Moldova
6	Cameroon	28	Nepal
7	Caribbean	29	Nigeria
8	Central America	30	Philippines
9	Central Asia	31	Senegal
10	Dominican Rep	32	South Africa
11	East Africa	33	SE Asia
12	Ecuador	34	South Asia
13	Egypt	35	Taiwan
14	Ethiopia	36	Tajikistan
15	Gambia	37	Tanzania
16	Guatemala	38	Turkmenistan
17	Guinea	39	Uganda
18	Honduras	40	Ukraine
19	India	41	Uzbekistan
20	Indonesia	42	Vietnam
21	Jamaica	43	W. Africa
22	Jordan		

Gender Equity

Maria Elisa Christie, Virginia Tech

The IPM CRSP continued to make advances in gender equity in 2008 - 2009, from individual program efforts to the highlight of the year, a gender workshop in Mali in June, organized by the Management Entity and with specific direction and support from Don Mullins, Program Leader of the West Africa regional program. This workshop will serve as a template for future such gender workshops that may be held by the ME or by host country gender experts.

Gender Workshop in Mali

The workshop—*Gender, Participatory Research, and Technology Transfer*—was held June 15th – 18th at the Office of the Irrigated Perimeter of Baguinéda (OPIB), a regional center outside of the capital of Bamako. The workshop drew 30 researchers, extension agents, and representatives from institutions in West Africa that partner with the IPM CRSP. As part of the workshop, participants presented IPM no-host period technology and also carried out research with 298 farmers.

The primary objectives were to:

1. Increase gender awareness and commitment to gender issues in the West Africa Program
2. Build host country capacity to increase equity, empowerment, and sustainability through gender-sensitive research and participative methodologies
3. Understand how gender issues and women's participation play a role in the success of IPM objectives
4. Increase the profile of gender issues and activities in IPM CRSP programs
5. Identify gender-based constraints and opportunities in the West Africa Program

The objectives presented to workshop participants were to:

1. Learn key concepts
2. Understand how gender and women's participation play a key role in the success of IPM objectives
3. Begin gender analysis and integrate results in the IPM CRSP project at Baguinéda
4. Identify constraints and opportunities related to gender

A pre-workshop training was held to train the trainers on June 1, 2, 3, 9, and 10. These sessions took place at the Institut du Sahel (INSAH) in Bamako. A post-workshop evaluation session with group leaders was also held at INSAH on June 19th.

Workshop materials, presentations and group work were in French; work with the farmers—including access and control resource maps and activity profiles—took place in the local language, Bambara. The workshop opened with speeches by the director of the host institution, OPIB, and by the IPM CRSP regional coordinator on behalf of the director of INSAH. It included a presentation on women and gender issues in Mali by Mah Koné Diallo, gender expert at OPIB, and a presentation by Christie introducing the different components of the workshop as well as general information on gender and agriculture. Issa Sidibé, head of research at the Office of the Upper Niger Valley (Office du Haute Vallée du Niger, or OHVN) made a presentation on the IPM

CRSP program in Mali as well. A slideshow on gender roles and one on participative methodologies were presented as well, and served as a basis for activities. Posters on the same topic were also used in the workshop.

The workshop developed the capacity of local gender experts as well as producing materials to develop a prototype for carrying out similar workshops in the future. The presence of the IPM CRSP Communications Director, Miriam Rich, ensured documentation of the workshop and future dissemination through various media, and was essential to on-site preparation of materials and general logistical support throughout. The workshop built on local expertise, and it underlined the importance of gender experts in IPM CRSP institutions. For example, At OPIB, this was Hadji Diakite; for OHVN, Mah Koné Diallo; for the Institut d'Economie Rurale (IER), Kebé Marie Cecile Sidibé, who is also the expert in the Ministry of Agriculture on a special project. The workshop and collaboration with local gender experts was preceded by a visit to the region by the IPM CRSP ME gender coordinator nearly two years prior; without the relations established during that visit, the workshop would not have happened.

The workshop was successful from the standpoint of meeting the objectives and achieving full participation of a very heterogeneous group, but its true success can only be measured by the extent to which gender concerns are integrated into the future work of the IPM CRSP, and into the future work of participating institutions.

Already at the day-after-the-event evaluation session, some interesting things were learned. Team leaders shared how they saw participants' comprehension of the term "gender" evolve. Participants, they said, came to understand the following:

1. Gender is different from biological sex.
2. Gender is a participative approach which allows one to take into account the heterogeneity of the group and achieve qualitative and sustainable results.
3. It is important to work with men and women, young and old, who may have different interests and concerns.
4. Working with different genders and ages permits one to take socio-cultural issues and intervening negative forces into account.

It is clear that there are many research findings and data from the fieldwork that must yet be mined for opportunities and constraints. Two weeks after the workshop, agricultural economics student Théodore Neuhoheflin reported incorporating gender analysis into his fieldwork, and extension staff at OPIB identified women's lack of access to IPM information and training as an issue. Also as a result of the workshop, gender has been integrated into the Agence Nationale de Conseil Agricole et Rurale (ANCAR) in Senegal. It remains to be seen if institutions change their way of doing business to address these issues.

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

Dr. Colette Harris, University of East Anglia, UK
Dr. Carmen Suarez, INIAP Ecuador (El Instituto Nacional Autónomo de Investigaciones Agropecuarias)
Dr. Jeffrey 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 had been 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, empowering them to adopt new farming practices.

Significant changes in relation to gender are evident. Participation of women in one of the IPM groups that was evaluated has increased from zero to nearly 50 percent. This has resulted in male 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' contributions.

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, PhD Candidate, The Ohio State University
Dr. J. Mark Erbaugh, 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 comparisons on issues including access to resources, the division of labor, the 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 pesticide safety procedure practices, such as the observation of the 12-hour post-application waiting period and secure storage of pesticides.

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
Dr. Maria Elisa Christie, Program Director for Women in International Development and Gender Equity Coordinator for the IPM CRSP Management Entity

Field data was collected via surveys, interviews, and focus group discussions during July 2008 to identify the gender issues associated with the adoption of IPM by tomato producers in Wakiso District, Uganda. GPS-coordinated data was also collected at locations of agricultural inputs, markets, meeting places, and farmer 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 the questions and problems they face. This project was carried out in conjunction with the IPM CRSP East Africa program.

TRAINING AND INSTITUTIONAL CAPACITY DEVELOPMENT

Long-Term Degree Training

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

- Six U.S. Universities, one Swedish University and seventeen host country universities provided long-term training for 57 graduate students (25 PhD and 32 M.S.) and 33 undergraduate students associated with IPM CRSP activities.
- Of these 57 graduate students 50 are from developing countries and 7 from the U.S.
- 29 are men and 28 are women.
- Their specializations in the graduate program:
  - Agriculture – 12
  - IPM – 13
  - Agricultural/Applied Economics – 7
  - Plant Pathology – 4
  - Entomology – 6
  - CropScience/Protection – 4
  - Plant Virology – 2
  - Horticulture – 2
  - Plant Biotechnology – 1
  - Insect Pathology – 1
  - Plant Ecology – 1
  - Gender Issues – 1
  - Sociology – 1
  - Weed Science – 1
  - Landscape Ecology – 1
- The number of trainees trained by programs: Southeast Asia – 10, South Asia – 3, Central Asia – 14, East Africa – 10, West Africa – 2, Latin America and the Caribbean – 2, Parthenium – 4, Impact Assessment – 5, Insect Transmitted Viruses – 3, and Thrips-borne Tospoviruses – 4. (Table 1)

Table 1: Long-Term Degree Training Participants by Country, FY 2009

Program	Doctorate		Masters’		Total
	Men	Women	Men	Women	
Cameroon	1	0	0	0	1
Macedonia	0	0	0	1	1
Dominican Republic	0	0	0	1	1
Ethiopia	0	0	3	1	4
India	2	2	0	0	4
Indonesia	3	3	3	0	9
Jamaica	0	1	0	0	1
Kenya	1	1	1	1	4
Kyrgyzstan	0	1	4	9	14
Nepal	0	0	1	0	1
Philippines	0	1	0	3	4
Senegal	2	0	0	0	2
Tanzania	0	0	1	0	1
Tajikistan	2	0	0	0	2
Uganda	1	0	1	2	4
USA	1	1	1	0	3
Benin	0	0	1	0	1
Total	13	10	16	18	57

Table 2: IPM CRSP Degree Training Participants (Graduate Students): FY 2009

Student Name	Sex (M/F)	Nationality	Discipline	University	PhD/MS	Start Date	End Date	IPM Program	Guide/ Advisor
Theodore Nouhohefliin	M	Benin	Agricultural Economics	Virginia Tech	MS	2008	2009	Impact Assessment	George Norton
Leke Walter Nkeabeng	M	Cameroon	Plant Virology	Swedish University of Agricultural Science (SLU)	PhD	2007	2010	Insect Transmitted Viruses Global Program	Anders Kvarnheden
Xiomara Cayetano Belen	F	Dominican Republic	IPM	Universidad Autonoma de Santo Domingo	MS	2005	2008	Insect Transmitted Viruses Global Program	Reina Teresa Martinez
Ebissa, Kuma	M	Ethiopia	Plant Ecology	Haramaya University	MS		2008	Parthenium Global Program	Wondi Mersie
Shikur, Srara	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	Washington State University	PhD	2009	2013	Thrips-borne Tospoviruses Global Program	Naidu Rayapati
Anitha Chitturi	F	India	Entomology	University of Georgia	PhD	2007	2010	Thrips-borne Tospoviruses Global Program	Riley
Rajwinder Singh	M	India	Entomology	Penn State University	PhD	Sept 2006	2010	South Asia Regional Program	Edwin Rajotte
S. Sivamani	F	India	Plant Biotechnolog y	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 Regional Program	Danje Sembelo
Sonya Lumowa	F	Indonesia	IPM	University of Mulawarman	PhD	2005	2009	Southeast Asia Program	Danje Sembel
Titov Manoi	M	Indonesia	Entomology	Sam Ratulangi University	MS	Sept 2008	Sept 2010	Southeast Asia Regional Program	Danje Sembel
Betsy Pinaria	F	Indonesia	Insect Pathology	Sam Ratulangi University	PhD	2005	2010	Southeast Asia Program	Danje Se,be;
Edi Susiawan	M	Indonesia	Entomology	Bogor University	PhD		2009	Southeast Asia Regional Program	Aunu Rauf
Sonia Lumowa	F	Indonesia	Entomology	Sam Ratulangi University	PhD	2007	2009	Southeast Asia Regional Program	D.T. Sembel
Lukman	M	Indonesia	Crop Protection	Bogor University	PhD		2009	Southeast Asia Regional Program	Amri Jahi
Deiby Tumilaar	M	Indonesia	Agronomy	Sam Ratulangi University	MS	Sept 2008	Sept 2010	Southeast Asia Regional Program	Jantje Pongoh
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		Oct 2008	East Africa Regional Program	
Miriam Judith Otipa	F	Kenya	Plant Pathology	JKUAT	PhD		Dec 2008	East Africa Regional Program	Elijah Ateka Edward Mamati 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	2007	2009	East Africa Regional Program	Ruth Amata

Abdurasulov, Quban	M	Kyrgystan	IPM	Kyrgyz Agrarian University	MS	Nov 2008	Sept 2009	Central Asia Program	
Dushenbieva, Asel	F	Kyrgystan	Landscape Ecology	Kyrgyz Agrarian University	MS	April 2007	Sept 2008	Central Asia Program	
Ishimova, Nargiza	F	Kyrgystan	IPM	Kyrgyz Agrarian University	MS	Nov 2008	Sept 2009	Central Asia Program	
Jekirov, Emil	M	Kyrgystan	Agriculture	Kyrgyz Agrarian University	MS	March 2008	Sept 2008	Central Asia Program	K. Junusov
Jolpon-Aqbermet Bakirova	F	Kyrgystan	Agriculture	Kyrgyz Agrarian University	MS	March 2008	Sept 2008	Central Asia Program	K. Junusov (KAU) Murat Aitmatov
Kerimbaeva, Aijan	F	Kyrgystan	IPM	Kyrgyz Agrarian University	MS	Nov 2008	Sept 2009	Central Asia Program	
Khigai, Ivan	M	Kyrgystan	Agriculture	Kyrgyz Agrarian University	MS	March 2008	Sept 2009	Central Asia Program	Nurali Saidov Janil Chelpakova
Mambetova, Saltanat	F	Kyrgystan	IPM	Kyrgyz Agrarian University	MS	Nov 2008	Sept 2009	Central Asia Program	
Nariev, Kairat	M	Kyrgystan	Agriculture	Kyrgyz Agrarian University	MS	March 2008	Sept 2008	Central Asia Program	Nurali Saidov Janil Chelpakova
Sayakbaeva, Aidai	F	Kyrgystan	Agriculture	Kyrgyz Agrarian University	MS	March 2008	Sept 2008	Central Asia Program	B. Masaitov Murat Aitmatov
Temirov, Nazgul	F	Kyrgystan	IPM	Kyrgyz Agrarian University	MS	Nov 2008	Sept 2009	Central Asia Program	
Kalibek, Jinara ova	F	Kyrgystan	Agriculture	Kyrgyz Agrarian University	MS	March 2008	Sept 2008	Central Asia Program	K. Junusov Murat Aitmatov

Qarieva, Elnura	F	Kyrgystan	IPM	Kyrgyz Agrarian University	MS	Nov 2008	Sept 2009	Central Asia Program	
Qosimova, Kiyal	F	Kyrgystan	Agriculture	Kyrgyz Agrarian University	PhD	March 2008	Sept 2008	Central Asia Program	Dr. Murat Aitmatov
Tatjana Hristovska	F	Macedonia	Agricular Economics	Virginia Tech	MS	2008	2009	Impact Assessment	George Norton
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	Oct 2008	Impact Assessment Global Program	George Norton
Catherine Aragon	F	Philippines	Agricultural Economics	Vrginia tech	MS		May 2009	Impact Assessment	George Norton
Myra Clarisse Ferrer	F	Philippines	Applied Economics	Clemson University	MS	Aug 2006	Oct 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
Fred Magina	M	Tanzania	Crop Science/ Crop Protection	Sokoine University	MS	Sept 2006	Oct 2008	East Africa Regional Program	A. Maerere
Davlatov, Abdulaziz	M	Tajikistan	IPM/Ag.	Institute of Zoology and Parasitology of Tajik Academy of Agricultural Science.	PhD	Dec 2006	Dec 2010	Central Asia Program	Dr. Nurali Saidov

Mirzoev, Tavakal	M	Tajikistan	Agriculture	Institute of Plant Production of Tajik Academy of Agricultural Science.	PhD	Dec 2007	Dec 2010	Central Asia Program	Dr. Nurali Saidov
Scovia Adikini	F	Uganda	Plant Pathology	Makerere University	MS	2007	2008	IITA and East Africa Regional Program	Mildred Ochwo-Ssemakula
Patrick Kucel	M	Uganda	Crop Protection	Makerere University	PhD	Oct 2006	Sept 2009	East Africa Regional Program	S. Kyamanywa, J. Ogwang, J Kovach
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
Jason Beddow	M	USA	Agricultural Economics	University of Minnesota	PhD	Aug 2005	Oct 2008	Impact Assessment Global Program	Philip Pardey
Elizabeth Crawley	F	USA	Sociology	University of Denver	MS	2007	2009	Latin America and Caribbean Regional Program	Sara Hamilton
Adam Sparger	M	USA	Agriculture	Virginia Tech	PhD	June 2009	2012	Latin America and Caribbean Regional Program	Jeffrey Alwang

Table 3: IPM CRSP Degree Training Participants (Bachelor's Degree Students): FY 2008

	Name of the Student	Gender M/F	Program
1	Arcos, D.	M	Latin American and the Caribbean Regional Program
2	Clavijo, F.	M	Latin American and the Caribbean Regional Program
3	Troya, Roberto	M	Latin American and the Caribbean Regional Program
4	Revelo, Stalin	M	Latin American and the Caribbean Regional Program
5	Manangón, L.	F	Latin American and the Caribbean Regional Program
6	Jarrín, J.	M	Latin American and the Caribbean Regional Program
7	Pazmiño, G.	M	Latin American and the Caribbean Regional Program
8	Sevilla, J.		Latin American and the Caribbean Regional Program
9	Jimenez, O.		Latin American and the Caribbean Regional Program
10	Vivanco, D.		Latin American and the Caribbean Regional Program
11	Suazo, O.		Latin American and the Caribbean Regional Program
12	Nolasco Isaula, L. Y.		Latin American and the Caribbean Regional Program
13	Muñoz López, M.F.		Latin American and the Caribbean Regional Program
14	Telenchana, J. A.		Latin American and the Caribbean Regional Program
15	Rosero, Gabriel Alejandro	M	Latin American and the Caribbean Regional Program
16	Abigaba, Michael	M	West Africa Regional Program
17	Kaweesi, Thaddeus	M	
18	Muwanga, Zachary	M	East Africa Regional Program
19	Magina, Fredrick	M	East Africa Regional Program

20	Agamile Peter	M	East Africa Regional Program
21	Odong Caeser	M	East Africa Regional Program
22	Charles Ssemwogerere	M	East Africa Regional Programs
23	Muwanika Chris	M	East Africa Regional Program
24	Tom Omara	M	East Africa Regional Program
25	Rosemary Namusisi	F	East Africa Regional Program
26	Adolf Saria	M	East Africa Regional Program
27	Anna Baltazari	F	East Africa Regional Program
28	Andrew Elias	M	East Africa Regional Program
29	S. Gabung	F	Southeast Asia Regional Program
30	N. Korompot	M	Southeast Asia Regional Program
31	D. Iriandy Lapasi	M	Southeast Asia Regional Program
32	Edwin Girón	M	Insect Transmitted Viruses Global Program
33	Marcelino Guachambala	M	Insect Transmitted Viruses Global Program
	Total	**33 Students**	

Short-Term Training

During the FY 2009, IPM CRSP held over 312 short-term training events serving more than 91438 persons. IPM CRSP activities were held in 17 different developing countries with the host country collaborators active cooperation. Fifty seven workshops, 35 conferences/seminars, 82 meetings, 117 training sessions, 17 field days, and 2 surveys were held to impart various technologies to stakeholders. Sex dis-aggregated counts were not made for all training events.

Table 4: IPM CRSP Non-Degree Training (Participant Summary), FY2009

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	Unk	Unk	Unk	Unk	Unk	406	**406**
East Africa – Regional Program	30	427	74	0	0	0	**531**
West Africa – Regional Program	401	623	0	600	0	0	**1,624**
Southeast Asia – Regional Programs	11	1,418	110	133	780	512	**2,964**
South Asia – Regional Program	485	518	Unk	0	80,070	0	**81,073**
Central Asia – Regional Program	0	197	58	0	107	770	**1,132**
Eastern Europe – Regional Program	471	90	4	0	0	100	**665**
Global Programs							
Parthenium Project – Global Program	236	194	78	0	0	585	**1,093**
IPDN – Global Theme Program	100	121	Unk	Unk	Unk	0	**221**
Thrips-borne Tospoviruses- Global Program	253	610	22	0	0	312	**1,197**
Insect Transmitted Viruses – Global Theme Program	28	26	20	0	Unk	458	**532**
Impact Assessment – Global Theme Program	0	0	0	0	0	Unk	**Unk**
Total Participants at IPM CRSP Events	**2,015**	**4,224**	**366**	**733**	**80,957**	**3,143**	**91,438**

Table 5: IPM CRSP Non-Degree Training (Activity Summary), FY2009

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	23	10	0	0	2	7	**42**
East Africa – Regional Program	1	9	6	0	0	0	**16**
West Africa – Regional Program	5	12	0	1	0	0	**18**
Southeast Asia – Regional Programs	2	29	18	3	2	5	**59**
South Asia – Regional Program	2	13	42	0	3	0	**60**
Central Asia – Regional Program	0	9	1	0	3	8	**21**
Eastern Europe – Regional Program	3	5	3	0	0	3	**14**
Global Programs							
Parthenium Project – Global Program	11	8	5	0	0	4	**28**
IPDN – Global Theme Program	6	6	1	0	0	0	**13**
Thrips-borne Tospoviruses- Global Program	0	10	1	0	5	3	**19**
Insect Transmitted Viruses – Global Theme Program	4	6	5	0	2	3	**20**
Impact Assessment – Global Theme Program	0	0	0	0	0	2	**2**
Total IPM CRSP Events	**57**	**117**	**82**	**4**	**17**	**35**	**312**

Table 6: IPM CRSP Non-Degree Training, FY 2009

Program Type	**Date**	**Training Type**	**Number of participants**	**Men**	**Women**	**Audience**
Latin America and Caribbean - Regional Program						
Workshop		Workshop training in Honduras	unknown	unknown	unknown	Farmers
Workshop		IPM for frosty pod of cacao	unknown	unknown	unknown	Farmers
Workshop		International workshop on diagnostic of plant Pathogens	unknown	unknown	unknown	Farmers
Workshop		IPM for solanaceous crops	unknown	unknown	unknown	Farmers
Workshop		IPM for tomatoes, cabbages, carrots and potatoes	unknown	unknown	unknown	Farmers
Workshop		Workshop on Safe Use of Agricultural Pesticides	unknown	unknown	unknown	Farmers
Workshop		IPM for plantains	unknown	unknown	unknown	Farmers
Workshop		IPM in tomatoes, cabbages and potatoes	unknown	unknown	unknown	Farmers
Workshop		Training in agricultural nematology techniques	unknown	unknown	unknown	Farmers
Workshop		IPM for cabbage, carrots and lettuce	unknown	unknown	unknown	Farmers
Workshop		IPM for tomatoes, onions and potatoes	unknown	unknown	unknown	Farmers
Workshop		IPM in lime production	unknown	unknown	unknown	Farmers
Workshop		IPM for onion insects and diseases	unknown	unknown	unknown	Farmers
Workshop		IPM for carrot diseases	unknown	unknown	unknown	Farmers
Workshop		IPM for diseases of vegetables and field crops	unknown	unknown	unknown	Farmers
Workshop		IPM for tomato diseases	unknown	unknown	unknown	Farmers
Workshop		IPM for downy mildew of cucumber	unknown	unknown	unknown	Farmers
Workshop		IPM in lettuce diseases	unknown	unknown	unknown	Farmers
Workshop		IPM for insects and diseases of peppers and tomatoes	unknown	unknown	unknown	Farmers
Workshop		IPM for insects and diseases in temperate climate vegetables, and safe pesticides use	unknown	unknown	unknown	Farmers
Workshop		Blackberry disease management	unknown	unknown	unknown	Farmers
Workshop		IPM for Andean Fruits	unknown	unknown	unknown	Farmers
Workshop		IPM for plantains and cacao	unknown	unknown	unknown	Farmers
Field Day		Identification of spray lances and rigs together with variations in foliar spray volume for improved management of onion thrips	unknown	unknown	unknown	Farmers
Field Day		Implementation of good farm practices in blackberry crops	unknown	unknown	unknown	Farmers
Other		IPM for postharvest diseases of fruit and vegetables	unknown	unknown	unknown	Farmers
Other		Plant disease management	unknown	unknown	unknown	Farmers
Other		Plantain disease control	unknown	unknown	unknown	Farmers
Other		IPM in plantain	unknown	unknown	unknown	Farmers
Other		IPM for plantains	unknown	unknown	unknown	Farmers

Other		IPM for Andean fruits	unknown	unknown	unknown	Farmers
Other		IPM for plantains and cacao	unknown	unknown	unknown	Farmers
Other		Farmer training	unknown	unknown	unknown	Farmers
Other		Basic Plant Pathology	unknown	unknown	unknown	Farmers
Other		Introduction to nematology and plant pathology	unknown	unknown	unknown	Farmers
Conference with 6 presentations		XI International Congress on IPM of the Mesoamerican region was held in Tegucigalpa under the leadership of Zamorano University and with FHIA as the co-leader.	406	304	102	Agricultural professionals and students
Total Participants in the Latin America and Caribbean - Regional Program			**406**	**304**	**102**	
Program Type	**Date**	**Training Type**	**Number of participants**	**Men**	**Women**	**Audience**
East Africa – Regional Program						
Research Training	2009	Thaddeus Kaweesi (Research assistant- Horticulture Program, NaCRRI) trained in the use of PCR in virus characterizations in the lab of Dr. Mildred Ochwo-Ssemakula.	1	1	0	Horticulture research assistant NaCRRI
Research Training	2009	Michael Abigaba (undergrad in BS ag program at Makerere University) was trained on viral disease epidemiology in the lab of Dr. Mildred Ochwo-Ssemakula.	1	1	0	Ag. undergraduate
Workshop	2009	One day workshop organized by NaCRRI and opened by IPM CRSP East Africa presented preliminary results of the passion fruit epidemiology trial as well as a PhD proposal on passion fruit breeding that builds ont eh recent PhD research of Dr. Mildred Ochwo-Ssemakula on passion fruit viruses in Uganda	30	20	10	Scientists and professionals
Farmer Training	October 14-16, 2008	Kenya: implemented pesticide safety and usage program with KARI at Kenyan research site at Mwea.	23	15	8	Tomato farmers and extension workers
Farmer Training	28 Feb. 2009	Uganda: Mpigi District, Buwama sub county, Scotch Bonnet Farmer Open Day	10	5	5	Scotch bonnet farmers
Farmer Training	25 June 2009	Uganda: Wakiso District, Busukuma sub-country, farmer demonstrations of tomato IPM package followed award program for Farmer Field School participants.	32	23	9	Tomato farmers
Farmer Training	May-Oct 2009	Tanzania: Day-to-day managemtn of the demonstration plots throughout the crop cycle from when nurseries were established in May to harvest in October. Participants attended from Mlali (8) and Misegese (13).	22	10	11	Farmers
Farmer Training	2009	Tanzania: farmers participated in a tomato field day. The training was conducted during the programmed visitst to	55	22	33	Farmers and 2 extension agents

		demonstration plots to disseminate IPM practices. During the training each farmer group was provided with standard pesticide application protective gear.				
Farmer Training	2009	Uganda: farmers were trained in Mbale and Sironko districts on different aspects of Arabica coffee production, such as the aspects of general management of Aravica coffee, integrated pest management in Arabica coffee safety measures in pesticides use, and record keeping and coffee production as a business	174	141	33	farmers
Farmer Training	2009	Tanzania: training on safe use of pesticides and botanicals was provided for extension agents and farmers. The training was conducted for farmers at botanical gardens. A total of 109 were trained at Uswaa, Mrimbo, Uuwo and Mawanjeni villages.	109	81	28	farmers
Meeting	14-16 Oct 2008	Social scientists meeting/KARI - Thiska	8	4	4	Social scientists
Meeting	1-2 March 2009	Kampala RTC mtg.	22	12	10	
Meeting	26 June 2009	Uganda site meeting	24	15	9	Co-PI's and grd students
Meeting	22-23 June 2009	Kenyan site meeting	5	1	4	PI and Co-PI's
Meeting	21-23 Sept 2009	Kampala RTC meeting	8	3	5	
Meetings	2009	USA Co-PIs visited sites throughout the year	7	6	1	USA scientists
Total Participants for the East Africa – Regional Program			**531**	**360**	**170**	

West Africa – Regional Program						
Workshop	2009	Field technicians were trained on producers' questionnaires in Mali including eight enumerators and for data managers which included perceptions and awareness of insects and virus attacks and losses to tomato, producer's knowledge and strategies for pest control factors affecting the adoption of the host-free period and of virus-tolerant tomato production management	19	Unknown	Unknown	Field technicians
Workshop	2009	Field technicians were trained in Senegal on producers' questionnaires which included perceptions and awareness of insects and virus attacks and losses to tomato, producer's knowledge and strategies for pest control factors affecting the adoption of the host-free period and of virus-tolerant tomato production management	11	Unknown	Unknown	Field technicians
Survey	2009	A survey was conducted in Mali in two major tomato production areas: Baguineda, where IPM activities (host-free period and improved tomato varieties) were intensively developed and Kati, where the IPM program is not yet implemented.	600	Unknown	Unknown	Farmers
Workshop Gender	15-18 June 2009	A gender workshop was conducted in Baguineda. It was sponsored by the WA IPM CRSP and hosted by the Office of Irrigated Perimeter of Baguineda (OPIB) in Mali. Participants were trained in gender awareness, gender analysis, and participative methodologies.	328	Unknown	Unknown	Researchers, extension agents, representatives from West African institutions, farmers
Workshop	16-20 Feb. 2009	IPDN workshop co-sponsored by the West African program to support the new plant disease diagnostic laboratory at IER Sotuba.	34	Unknown	Unknown	Scientists and extension agents
Training	2009	A Ph.D. student at the University of Dakar, Theis, Senegal attended intensive English language training.	1	1	0	Student/scientist
Training	2009	Pesticide safety training was conducted in ten villages in Mali	Unknown	Unknown	Unknown	Farmers
Training	Summer 2009	Train the trainer sessions were conducted for field agents based in Bamako, Bougouni, Fana, Kita, Koulikoro, Koutiala, San, and Sikasso.	30	Unknown	Unknown	Field Agents
Training	2009	Subsequent training resulting from the train the trainer sessions. Seven training sessions were held.	200	Unknown	Unknown	Farmers
Training	2009	IPM technology transfer training to train farmers and extension specialists on the use of pesticides with low	Unknown	Unknown	Unknown	Farmers

		toxicity to humans and animals and have low persistence in the environments and to educate producers of methods based on IPM. Booklets designed by VT, IER, and OHVN were distributed at the end of the training.				
Training	2009	Pesticide safety training coordinated by IER was conducted in 3 areas in the region of Segou.	111	61	50	Farmers producing cowpea
Training (3)	2009	Evaluating the effectiveness of ethyl chloropyrifos in mango cochineal control training sessions were conducted in three villages of Sikasso.	48	Unknown	Unknown	Mango farmers
Training	August 2009	Training on the safe use of pesticides was conducted in collaboration with CMDT, OHVN, IER, and IPM CRSP. The training was led by Mr. Issa Sidibe of OHVN, Mr. Ousmane Cisse of CMDT and Mr. Sidiki Traore of IER.	Unknown	Unknown	Unknown	Trainers, cotton farmers, and storekeepers of agricultural inputs.
Training of trainers	2009	Training of trainers was held in OHVN area Ouelessebougou.	30	Unknown	Unknown	OHVN trainers and CMDT trainers
Training of producers and stores persons	2009	Training of producers and stores persons was held in Ouelessebougou, Bougouni, Sikasso, Koutiala, San, Dioila, and Kita areas. During the sessions, booklets on the safe use of pesticides and IPM technologies were distributed.	203	Unknown	Unknown	Producers and stores persons
Workshop	Sept 14-16 2009	A three day workshop on QuECHERS was held in West Africa. Pesticide residue training at the Laboratory of Toxicology and Environmental Toxicology and Quality Control Laboratory (ETQCL) of the Central Veterinary Laboratory of Banako and the CERES-Locustox Foundation of Dakar	9	Unknown	Unknown	Scientists, laboratory technicians, and university students
Total Participants for the West Africa – Regional Program			**1624**	**62**	**50**	
Southeast Asia – Regional Program						
Farmer Training	8 May 2009	Training on the mass-production of Trichoderma harzianum. Topics included preparation of corn media, putting media into plastic bags, hand apparatus sterilization techniques, and inoculating media with hypae of Trichoderma.	25	15	10	Farmer group Intisari from the village of Cikanyere
Farmer Training	26 May 2009	Training on the mass-production of Trichoderma harzianum. Topics included preparation of corn media, putting media into plastic bags, hand apparatus sterilization techniques, and inoculating media with hypae of Trichoderma.	23	19	4	Farmer group Agro Segar from the village of Sindagjaya
Farmer Training	9 June 2009	Training on the mass-production of Trichoderma harzianum. Topics included preparation of corn media,	16	7	9	Farmer group Megah from the village of Sukatani

		putting media into plastic bags, hand apparatus sterilization techniques, and inoculating media with hypae of Trichoderma.				
Farmer Training	29 June 2009	Training on the mass-production of Trichoderma harzianum. Topics included preparation of corn media, putting media into plastic bags, hand apparatus sterilization techniques, and inoculating media with hypae of Trichoderma.	30	16	14	Farmer group Sinar Tani from the village of Bantarsari
Farmer Training	4 August 2009	Training on the mass-production of Trichoderma harzianum. Topics included preparation of corn media, putting media into plastic bags, hand apparatus sterilization techniques, and inoculating media with hypae of Trichoderma.	25	19	6	Farmer group Multitani Jayagiri from the village of Cipendawa
Seminar	22 Dec. 2008	IPM in horticultural crops in Bandung. Organized by BPTPH	unknown	unknown	unknown	Pest observers in most districts of West Java
Farmer Training		Special training on the mass production and field application of local strain metarhizium anisopliae. The training included insect identification infected by pathogenic fungi and the pathogenic fungi that had infected them.	25	4	21	Farmers from Modoinding, Sulawesi
Seminar	3 July 2009	One day seminar on all IPM CRSP research and training activities. 12 papers were presented and discussed.	Unknown	Unknown	Unknown	Entomology and agronomy professionals from the US and North Sulawesi
Farmer Field Study	September 2008 to June 2009	Ecological Vegetable Agriculture conducted in Doulu village, in collaboration with local Watershed Management Forum/Community Network "Ersinalsal Lembah Sibayak".	11	5	6	Farmers from the Sibayak Valley area (Berastagi Sub-district, Karo district) in the village of Doulu
Farmer Training 1	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	15	9	6	Farmers in Lau Biang area Village of Serdang
Farmer Training 1	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	13	7	6	Farmers in Lau Biang area Village of Penampen
Farmer Training 2	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	12	7	5	Farmers in Lau Biang area Village of Tangkidik

Farmer Training 3	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	12	7	5	Farmers in Lau Biang area Siberteng
Farmer Training 4	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	12	12	0	Farmers in Lau Biang area Village of Kabung
Farmer Training 5	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	9	5	4	Farmers in Lau Biang area Village of Tanjung Barus
Farmer Training 6	Sep. 2008	Farmer field study and field school on citurs in the Lau Biang area. Organized by the local Watershed Management forum/community Network, JAE it covered experimentation to compare farmer practice with ecological treatments for improvements.	12	6	6	Farmers in Lau Biang area Village of Sari Manis
Meeting 1	August 2008	Meetings on the design and implementation of the farmer trainings on citrus.	Unknown	Unknown	Unknown	Farmers and scientists
Meeting 2	August 2008	Meetings on the design and implementation of the farmer trainings on citrus.	Unknown	Unknown	Unknown	Farmers and scientists
Meeting 3	August 2008	Meetings on the design and implementation of the farmer trainings on citrus.	Unknown	Unknown	Unknown	Farmers and scientists
Meeting 4	August 2008	Meetings on the design and implementation of the farmer trainings on citrus.	Unknown	Unknown	Unknown	Farmers and scientists
Meeting 5	August 2008	Meetings on the design and implementation of the farmer trainings on citrus.	Unknown	Unknown	Unknown	Farmers and scientists
Meeting		A bi-weekly meeting on agroecosystem analysis and special topics	Unknown	Unknown	Unknown	Farmers and scientists
Farmer Training	March-to April 2009	A study on Ecological Cacao Agroforestry in Sibolangit conducted by the farmer network FPK. Formasi helped to implement the program and disseminate the results. Funding and technical support were provided by FiELD and CLEMSON "The effect of the use of plastic sleeve and sanitation for the management of Cacao Pod Borer."	6	4	2	Men and women from 3 villages in Sibolangit: Batu Layang, Rumah Pil-pil and Rumah Sumbul
Farmer Training	March to April 2009	A study on Ecological Cacao Agroforestry in Sibolangit conducted by the farmer network FPK. Formasi helped to implement the program and disseminate the results.	6	2	4	Men and women from 3 villages in Sibolangit: Batu Layang, Rumah Pil-pil and Rumah Sumbul

		Funding and technical support were provided by FiELD and CLEMSON "The effect of sanitation and organic fertilizer for the management of Dry Pod Disease."				
Farmer Training	March to April 2009	A study on Ecological Cacao Agroforestry in Sibolangit conducted by the farmer network FPK. Formasi helped to implement the program and disseminate the results. Funding and technical support were provided by FiELD and CLEMSON "The effect of pruning and organic fertilizer for cacao plant growth."	12	9	3	Men and women from 3 villages in Sibolangit: Batu Layang, Rumah Pil-pil and Rumah Sumbul
Meeting	July 7, 2009	Meeting with Ramdani Afriman and team leader Nofrizal	10	Unknown	Unknown	
Meeting	July 14, 2009	Meeting with Ramdani Afriman and team leader Nofrizal	10	Unknown	Unknown	
Meeting	July 21, 2009	Meeting with Ramdani Afriman and team leader Nofrizal	10	Unknown	Unknown	
Meeting	July 28, 2009	Meeting with Ramdani Afriman and team leader Nofrizal on weekly observation and agroecosystems analysis, sanitation, and Fertilizer application	10	Unknown	Unknown	
Meeting	August 4, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	
Meeting	August 11, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	
Meeting	August 18, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	
Meeting	August 25, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	
Meeting	September 1, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	
Meeting	September 8, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	

Meeting	September 15, 2009	Meeting with Ramdani Afriman and team leader Nofrizal weekly observation and agroecosystems analysis, sanitation, fertilizer application, and the observation of the sweet potato weevil *Cylas formicarius* lifecycle.	10	Unknown	Unknown	
Farmer Field School/Study	April 2009	Comparison study of the sweet potato weevil *Cylas formicarius.* "Attack on organic sweet potato's with Non Organic Sweet Potato's" and "Life Cycle Study of *Cylas formicarius"* Conducted by the Sajati Farmer Group of Jorong Sungai Sariak, Nagari Koto Tinggi, sub district of Baso, district of Agam	18	14	4	Farmers in the Village of Nagari Koto Tinggi
Seminar	12 Dec 2008	One-day training seminar on IPM CRSP pest management technologies	61	38	23	
Seminar	31 July 2008	One-day training seminar on IPM CRSP pest management technologies	61	38	23	
Training Activity	2008	Technical assistance to the "Gawad Kalinga" project, a combined housing and vegetable production project of the Department of Agriculture and the Couples for Christ, by giving lecture-demonstrations on IPM technologies and providing the project participants with biological control agents to manage vegetable pests	Unknown	Unknown	Unknown	Project participants/farmers
Training Seminar	12 Dec 2008	IPM in eggplant – eggplant grafting with hands-on training Training in cooperation witht eh Dept of Ag Local Government Unit of Calauan	39	16	23	Vegetable farmers from eight villages in Calauan, Laguna
Training Seminar	31 July 2008	IPM in eggplant – eggplant grafting with hands-on training and included the use of earwigs to manage insect pests of vegetables. Training in cooperation witht eh Dept of Ag Local Government Unit of Calauan	22	15	7	Vegetable farmers from eight villages in Calauan, Laguna
Technical Training	8 March to 21 May 2009	Technical assistance to a housing and vegetable production project of Dept of Ag and the Couples for Christ (CFC). Okra, eggplant, tomato, bittergourd, pechay, cabbage, crucifers and other vegetables. A demonstration was given on mass rearing of earwigs and grafting of tomato (scion) and bacterial wilt resistant variety of eggplant Eg203 (root stock) was conducted at the GK site in Sta Cruz Laguna.	30	Unknown	Unknown	GK project participants from different areas in the Philippines
Activity	June-Sept 2008	On-farm evaluation of promising component technologies to manage pests infesting eggplant in Calauan, Laguna	Unknown	Unknown	Unknown	Farmers
Activity		Dissemination of IPM CRSP technologies: Monitoring of pest incidence and crop yields in the Dept. of Ag *Gawad*	Unknown	Unknown	Unknown	Farmers

		Lakinga vegetable plots treated with IPM CRSP technologies.				
Meeting/Networking Activity	January 2009	Dr. Merle Shepard met in the Philipines with scientists and farmers to observe IPM CRSP experimental plots and the Gawad Kalinga vegetable plot sites in southern Luzon, Philippines and to discuss experimental results with UPLB IPM CRSP co-PIs	Unknown	Unknown	Unknown	IPM CRSP co-PIs, scientists and farmers
Seminar	5-8 May 2009	Opena, J.L and A.M. Baltazar presented "Integrated weed management using stale-seedbed and other cultural practices in eggplant and pechay in southern Luzon, Philippines" at the 40th conference of Pest management council of the Philippines.	Unknown	Unknown	Unknown	IPM professionals and students
Survey	2008	Survey of farmers in four villages of Calauan, Laguna, on their vegetable production and pest management practices	33	Unknown	Unknown	Farmers in the villages of Calauan and Laguna
Training of Trainers	2009	Two specialized training of trainers on vegetable IPM in rice-based cropping systems were conducted in collaboration with the Agricultural training Institute of Region, Sta. Barbara, Pangasinan in the Satellite Station in Batac, Ilocos Norte Training covered IPM on onion, eggplant tomato and bitter gourd.	63	35	28	Agricultural technologicst of the LGUs and researchers
Fermer training	2009	Five 2 day training programs on IPM in onion production were conducted in collaboration with the Municipalities and the Departmetn of Agriculture.	35	20	15	Agricultural technicians, professionals from the Office of the Provincial Agriculturist of Pangasinan and farmers.
Farmer training	2009	Farmer trainings were conducted in Bayambang, Pangasinan on onion IPM	227	164	63	Farmers fro several cities in the Pangasinan region
Farmer Field School	Oct 2008 to March 2009	FFS were conducted in collaboration with the Department of Agrarian Reform, Philippines. 74 Barangay were represented in these trainings	575	434	141	Farmers
	Oct 2008 to March 2009	DA Agricultural Technologists also attended the above FFS.	47	Unknown	Unknown	DA Agricultural Technologists
Farmer Training	October 2008-march 2009	Training and practicum on the mass production of VAM and Trichoderma sp. Was conducted on 16 sites. 4.225 tons of inoculants were produced.	704	534	170	Farmers
Trainings	October 2008-march 2009	DA Agricultural Technologists also attended the above Farmer Trainings	45	Unknown	Unknown	DA Agricultural Technologies
Seminar	Feb 10-13 2009	A seminar with technical briefings on Trichoderma were held in 2009	390	286	104	Farmers
Farmers Field	2009	A farmers field day was conducted in San Agustin, San	100	Unknown	Unknown	Farmers

Day		Jose City, Nueva Ecija coincided with the FFS graduation in the barangay				
Other	2009	Farmers Field School Graduation. Farmers received certificates on the use of VAM and Trichoderma	40	Unknown	Unknown	Farmers
Other	2009	An exhibit was displayed featuring the different IPM technologies promoted in the campaign during the farmers day. Free posters and flyers were handed out.	Unknown	Unknown	Unknown	Farmers and local residents
Campaign evaluation	2009	Two sets of focus group discussions were conducted in each of the focus barangays to gather farmers feedback on the campaign.	Unknown	Unknown	Unknown	Farmers
Survey	2009	Farmers outside the focus barangays to determine the extent of reach of the campaign	100	Unknown	Unknown	Farmers
Total Participants SoutheastAsia Regional Programs			**2964**	**1747**	**612**	

Program Type	**Date**	**Training Type**	**Number of participants**	**Men**	**Women**	**Audience**
South Asia – Regional Program						
Workshop	2009	A workshop with training for farmers was held in collaboration with the local NGOs. MCC organized a series of workshops for farmers to discuss improved cultivation of vegetables and implementation of IPM practices.	450	333	17	Farmers
Training	2009	MCC went on to organize six other training events to teach farmers about IPM practices in vegetable crops that was developed by IPM CRSP	150	124	26	Farmers
Farmers meetings	2009	MCC organized farmers meetings to discuss household production of vegetables in the farm yards	Unknown	Unknown	Unknown	Farmers families
Training	27-28 Sept 2008	Service providers and nursery growers participated in training organized by NARC and IPM CRSP/WI	92	Unknown	Unknown	Service providers and nursery growers
Trainings	2-3 June 2008	Service providers and nursery growers participated in training organized by NARC and IPM CRSP/WI	92	Unknown	Unknown	Service providers and nursery growers
Trainings	8-9 January 2009	Service providers and nursery growers participated in training organized by NARC and IPM CRSP/WI	92	Unknown	Unknown	Service providers and nursery growers
Trainings	13-14 September 2009	Service providers and nursery growers participated in training organized by NARC and IPM CRSP/WI	92	Unknown	Unknown	Service providers and nursery growers
Training workshop	2009	Training workshop on integrated vegetable grafting technology for managing soil-borne diseases and increasing tolerance to flooding to the hot-wet season at Tamil Natu Ag University, Coimbatore, India Trainers: Deng-Lin Wu, Gregory C. Luther and E.A. "Short"	35	17	18	Vegetable farmers- especially women farmers

		Heinrichs				
Farmers Field Day	8 June 2009	Farmers field day on IPM practice for vegetable crops was organized by TERI, N. Delhi at village Upeda near Babugarh Cant, Hapur at Mr. Niranjan Tyagi's brinjal field. Scientists from AVRDC, Taiwan; NCIPM, India: Teri and PCI staff briefed farmers about the various aspects of safe practices of pest management. More than 70 farmers of Upeda and nearby villages	70	60	10	Farmers
Demonstra-tions	2009	Demonstrations of IPM practices on vegetable crops at Farmers field in 8 villages in UP, 3 villages in AP, and 3 villages in Karnataka.	80000	Unknown	Unknown	Farmers including women
40 Group Meetings	2009	Vegetable IPM meetings were held	Unknown	Unknown	Unknown	Unknown
Farmers Meeting	2009	Farmers meeting on vegetable IPM	Unknown	Unknown	Unknown	Farmers
Field Days (many)	2009	Field days were organized to teach about vegetable IPM	Unknown	Unknown	Unknown	Farmers
Farmer Training	2008	Incorporation of neem cakes and *Paecilomyces* in soil for management of soil born problems	Unknown	Unknown	Unknown	Farmers
Farmer Training	2008	Seed treatment effect of *Trichoderma* and *Pseudomonas*	Unknown	Unknown	Unknown	Farmers
Farmer Training	2008	Biopesticide spray technique	Unknown	Unknown	Unknown	Farmers
Farmer Training	2008	Protective measures during biopesticides/pesticide spray	Unknown	Unknown	Unknown	Farmers
Farmer Training	2009	Infected shoot and fruit clipping for management of egg platn FSB	Unknown	Unknown	Unknown	Farmers
Farmer Training	2009	Nursery management techn iques	Unknown	Unknown	Unknown	Farmers
Farmer Training	2009	Mulching techniques in tomato	Unknown	Unknown	Unknown	Farmers
Farmer Training	2009	Neem spray making with neem seed kernels	Unknown	Unknown	Unknown	Farmers
Total Participants in the South Asia – Regional Program			**81073**	**534**	**71**	
Central Asia – Regional Program						
Seminar	5 Sept. 2009	A seminar on "Multiplication of new vegetable seeds, and management of diseases and pests on crops"in the Kibray region in Uzbekistan "Yangiobod Husanov Durbek farmes distric.	70	60	10	Farmers and regional releders including the mayor, the head of the farmers association, chairman of farms, and the director of

						AVRDC)
Farmer Training	17 April, 2009	Training for farmers, leaders and NGO represenatatives was held in Dushanbe, Tajikistan on "Introducing native flowering plants in existing agro-landscapes." (organized by Dr. Saidov)	25	20	5	Farmers, leaders, and NGO reps
Farmer Trainings	18 April 2009	Training for farmers, leaders, and NGO representatives was held in Kulob region of Tajikistan on "Introducing native flowering plants into existing agro-landscapes." (organized by Dr. Saidov)	25	25	0	Farmers, leaders, and NGO reps.
Field day for farmers	22-23 July 2009	Field day for farmers on IPM FFS featuring tomato pest control through IMP in the Kulob and Hissor region (organized by Dr. Saidov)	70	55	15	Tomato farmers
Student Field School		Student Field School	6	1	5	Students
Field Day	30 April 2009	Field day at the school for students	31	19	12	KAU teachers and students, ATC trainers and farmers.
Training	30 April 2009	Two reports were written by students from SFS during the International scientific conference in KAU. **Report 1.** Experiences of Field School of Students: The Device and Use of Kinds of Vegetative Hotbeds. Mambetova S., Temirova N., Kerimbaeva A. Students of three agronomical faculty (Ergeshova K.E., KAU senior lecturer, Aitmatov M. ICARDA-IPM CRSP). **Report 2.** Experiences of Field School of Students: Influence of Vegetative Pesticides and Stimulators on Growth and Similarity of Various Grades of the Tomato. Karieva E., Abdyrasulov K., N. Ishimova. Students of three agronomical faculties (Ergeshova K.E., KAU senior lecturer, Aitmatov M. ICARDA-IPM CRSP)	8	2	6	Agronomy students
Training	11 Nov 2008	Dr. Aitmatov conducted a one day training on the application of a biomethod and cultivation of sprouts of tomatoes in hotbeds in the village of Tuura-Suu of Ton district of Issyk-Kul province, Kyrgyzstan.	13	9	4	Farmers
Training	27 Dec 2008	Dr. Aitmatov presented a day-long training for residents of the village Toluk of Naryn province, Kyrgyzstan. "Introducing innovations into activities of FSF – strengthening agro-landscapes by means of nectariferous plants."	23	9	14	Farmers
Training of Trainers	30 March- 3 April 2009	Dr. Aitmatov participated in training for trainers by the Aga Khan Foundation in southern Kyrgyzstan. Participants learned skills for group facilitation in teaching IPM approaches.	13	10	3	Trainers

Trainers Exchange	10 March 2009	Dr. Aitmatov organized an exchange experience for trainers of ATC and the Japanese project JAICA from Tajikistan. Visitors were very interested in the kinds of hotbeds construction for warming vegetable seedlings. Students of the SFS gave short presentations about their research results at the SFS. Five people from Project JAICA (1 man and 4 women), two representatives ATC, 6 students of KAU (5 women and 1 man), two farmers (1 man and 1 woman) participatned in the session. Participants received leaflets about the three components of the Central Asia IPM CRSP Project.	15	6	9	Project JAICA people, representatives of ATC, Students of KAU and farmers
Training of Trainers	14-16 July 2009	Opening ceremony for the Center of Training of Trainers (CoToT) NGO, the Agrolead, working with potato IPM along with Dr. Aitmatov presented the CoToT concept. Others introduced the basic approaches and principles of the COTOT	53	39	14	Professionals and students and TV reps
Meeting	8 April 2009	Meeting with the director of the FAO in Kyrgyzstan, Dr. Sangiba Razhapovich. Participants discussed the IPP questions and joined the KAU in preparations for the project regarding potato pests. The project collaborators Dr. Anvar Umarovich-trainer (IPM CRSP), KAU scientists and the Agrolead NGO were involved.	Unknown	Unknown	Unknown	Professionals in government and non-govenrment offices
Regional IPM Forum	June 1-5 2009	Regional IPM forum to foster networking and share the research results and experiences of the Central Asia IPM CRSP project was organized in Bishkek, Kyrgyzstan. It was co-hosted by the Kyrgyz Agrarian University and the Ministry of Agriculture, Water Resources and Processing Industry in Kyrgyzstan in collaboration with ICARDA-CAC regional Program.	58	37	21	Professionals from government research institution, universities and NGOs from Kyrgyzstan, Tajikistan, Uzbekistan and Kazakhstan attended the forum program in Bishkek, as well as representatives from US universities
Training	June 3-4 2009	Pest Diagnostics Training Workshop in coordination with the Global Theme program on Pest Diagnostics. Facilitated by Sally Miller and Dr. Barry Jacobsen and presentations on endemic diseasesa caused by fungi, bacteria, viruses, nematodes and insect pests, and beneficial organisms.	22	12	10	Scientists from Kyrgyzstan, Tajikistan and Uzbekistan
Conference	2008	Tashpulatova presented ""Biological control of *Thrips tabaci* (Thysanoptera: Thripidae) using *Ambliseius mckenziei* (Acarina: Phytoseiidae) on onion crop in Kyrgyzstan and Uzbekistan." Conference for the 50th anniversary of Kaz. Scientific Research Institute of Plant Protection and Quarantine, Almaty-Kazakhstan in 2009	Unknown	Unknown	Unknown	Professionals

Conference	2008	Tashpulatova. 2008. "Studies of the predaceous mites *Amblyseius cucumeris* and *Amblyseius mckenziei* (Acari: Phytoseiidae) in Uzbekistan," Conference on "Application of methods of biological control in agriculture" in Tashkent, Uzbekistan.	Unknown	Unknown	Unknown	Professionals
Conference	2008	Tashpulatova. 2008. "Study of the possibility for introduction and application in Uzbekistan predator mites of the family Phytoseiidae." Conference on "Application of methods of biological control in agriculture" in Tashkent, Uzbekistan.	Unknown	Unknown	Unknown	Professionals
Conference	2008	Saidov, N. Sh. and D.A. Landis. 2009. "Enhancing pest management in organic farming via conservation biological control," The 2nd International Conference on organic sector development in Central/Eastern European and Central Asian countries held in Tbilisi, Georgia. The conference attracted more than 250 participants from 22 countries	250	Unknown	Unknown	Professionals
Conference	2008	Saidov N.Sh., D.A. Landis, A. Fiedler, V.K. Nazirov, and A. Khalimov. 2008. "The role of nectar plants on attraction natural enemies in agro-landscapes," Conference dedicated to the 60th Anniversary of Department of Biology of National University of Tajikistan in Dushanbe city.	Unknown	Unknown	Unknown	Professionals
Conference	2008	Saidov, N.Sh. and D.A. Landis. 2008, "Landscape ecology and biodiversity to enhance biodiversity and biological pest management". 9th International Conference on Dryland Development, Sustainable Development in the Drylands Meeting the Challenge of Global Climate Change, which was held in Alexandria, Egypt. The conference attracted more than 450 participants from 55 countries.	450	Unknown	Unknown	Professionals
Total Participants in the Central Asia – Regional Program			**1132**	**304**	**128**	
Eastern Europe – Regional Program						
Short-term Training	2008	Short-term agricultural sector productivity training	305	216	89	Agricultural professionals
Short-term Training	2009	Short-term agricultural sector productivity training	104	93	89	Agricultural professionals
Short-term Training	April 2009	Short-term Training on IPM in cooperation with the Ministry of Agriculture and Food Industry. Materials were	Unknown	Unknown	Unknown	Farmer groups

		distributed including systems for IPM, utilization of Trichogramma in plant protection systems, new methods of scouting and monitoring for ag pests and identifications of pests and diseases of vegetable crops and their natural enemies.				
Workshop	12 June 2009	Experimental fields demonstrations in “Ecologically safe methods for protection of vegetables” were organized together with Consulting Agency ACSA in Ocnita district.	19	Unknown	Unknown	Farmers and specialists
Workshop	22 June 2009	Experimental field demonstrations “Biological means in plant protection” was conducted in the Ialoveni district.	22	Unknown	Unknown	Farmers and specialists
Workshop	21 Sept 2009	“Integrated plant protection in greenhouses” with demonstrations and training. Workshop was organized in collaboration with Consulting Agency ACSA	17	Unknown	Unknown	Farmers and specialists
Seminar	2009	A seminar on intergrated system of strawberry and vegetable production was held on the farm “Pan Bilan” of Vilyayiv distric Odessa Region. Presented by Olena Cholovska	30	Unknown	Unknown	Farmers
Seminar	2009	A seminar on intergrated system of strawberry and vegetable production was held on the farm “Pan Bilan” of Vilyayiv distric Odessa Region. Presented by Olena Cholovska	35	Unknown	Unknown	Farmers
Meeting	2009	Plenary meetings in Odessa region scientists and farmers discussed questions of integrated growing of vegetables in Ukraine	Unknown	Unknown	Unknown	Scientists and farmers
Meeting	2009	Olena Cholovska and Myroslava Ishchuk participated in the 6th International IPM Symposium in Portland Orgegon USA	2	0	2	Scientists
Meeting	2009	Olena Cholovska and Myroslava Ishchuck participated in the meeting “Integrated Control in Progtected Crops, Mediterranean Climate” sponsored by the Internatioanl Organization for Biological Control, in chania Crete, Greece.	2	0	2	Scientists
Training	2009	A training course on IPM for tomatoes and cucumbers was conducted in the Dnipropetrovsk District	30	Unknown	Unknown	Farmers and scientists
Training	2009	A training course on IPM for tomatoes and cucumbers was conducted in the Pavlograd District	32	Unknown	Unknown	Farmers and scientists
Presentation	2009	“Prospects for IPM dissemination in Ukraine” was written and presented by Kateryna Maslikova, Mykola Kharytonov and Doug Pfeiffer	35	Unknown	Unknown	Farmers and scientists
Total Participants in the Eastern Europe – Regional Program			**711**	**309**	**182**	

Program Type	Date	Training Type	Number of participants	Men	Women	Audience
Parthenium Project – Global Theme						
Meeting	13-16 Oct 2008	The 4th parthenium partners reporting and planning workshop at the Imperial Hotel in Addis Ababa Ethiopia.	70	67	3	Professionals
Conference	23-27 June 2008	The 5th International Weed Science Congress in Vancouver Canada. S. Adkins gave a presentation on "Parthenium weed research aids management of this weed in the agro ecosystems of Ethiopia and Pakistan.	550	275	275	Professionals
Seminar	2008	Seminar at Kew Gardens, Wakehurst Place, England. S. Adkins gave a presentation on parthenium weed: an invasive weed of the agro ecosystems of Australia, Ethiopia and Pakistan.	35	18	17	Professionals
Workshop	13-15 October 2008	The 4th partners Planning and Reporting Regional Workshop, Addis Ababa, Ethiopia. J. Bisikwa gave a presentation on the status of invasive plant management in Uganda.	Unknown	Unknown	Unknown	Professionals
Workshop	26 Feb 2009	The EATRINET/UVIMA Awareness Workshop, Kampala, Uganda, Status of Invasive aliaen species in Ugandan Ecosystems featuring the case of parthenium weeds problem in Uganda.	Unknown	Unknown	Unknown	Professionals
Workshop	1-4 March 2009	The 5th Techn ical Committee Meeting and Profress Report Workshop of Integrated Pest Management. J. Bisikwa gave a presentation on Parthenium weed problem spreads to Uganda.	Unknown	Unknown	Unknown	Professionals
Conference	25-26 December 2008	The 9th Annual Conference of Ethiopian Weed Science Society in Hiruy Hall, at the Ethiopian Institute of Agricultural Research, Addis Ababa Ethiopia. M. Abebe and N. Mulugeta gave a presentation on screening for safety and mass production of bio-control agent (*Zygogramma bicolorata*), under quarantine conditions at PPRC, EIAR, Ambo, Ethiopia.	Unknown	Unknown	Unknown	Professionals
Workshop	2009	Invasive Weed Management Workshop and Field Day organized by Wondi sugarcane enterprise and UNEP/GEF project on "Removing barriers to invasive plant management". Kemal Ali, Mulugeta Negeri, and Takele Negweo were participants.	Unknown	Unknown	Unknown	Professionals
Conference	2009	The South African Crop Production/Soil Science Society of South Africa/South African Society for Horticultural	Unknown	Unknown	Unknown	Professionals

		Sciences/South African Weed Science Society Combined Congress at Sellenbosch University in Stellenbosch South Africa. J. taylor, K. Kirkman, A. McConnachie and L. Strathie gave a presentation on the Seed bank studies of the alien invasive weed, *Parthenium hysterophorus* L., in the eastern areas of South Africa.				
Workshop	13-16 October 2008	IPM CRSP parthenium project partners workshop in Addis Ababa Ethiopia. A. McConnachie gave a presentation on the parthenium districution studies – the relevance for biocontrol mass-rearing.	30	27	3	Professionals
Workshop	13-16 October 2008	IPM CRSP parthenium project partners workshop in Addis Ababa Ethiopia. A. McConnachie gave a presentation on Biological control of invasive plant species.	30	27	3	Professionals
Workshop	13-16 October 2008	IPM CRSP parthenium project partners workshop in Addis Ababa Ethiopia. L. Strathie gave a presentation on Biological control programmes and determining safety of agents.	30	27	3	Professionals
Workshop	13-16 October 2008	IPM CRSP parthenium project partners workshop in Addis Ababa, Ethiopia. L. Strathie gave a presentation on Rearing and testing agents for biological control of *Parthenium hysterophorus* in South Africa.	30	27	3	Professionals
Workshop	5-8 May 2009	37th Annual biocontrol of weeds workshop, green fountain farm, port Alfred. L. Strathie gave a presentation on Promising prosepects for biological control of *Parthenium hysterophorus*.	80	40	40	Biocontrol researchers implementers and managers
Workshop	19 May 2009	Biological Control of alien invasive plants. Ivungu river Conservancy with L. Strathie and C. Zachariades.	30	15	15	Public participants
Short-term Training	19-23 Jan 2009	Weed Biological Control Short Course at Rhodes University attended by Mr. Adegid Wegayehu Desta and Ms. Desta Tolessa Golbo, both laboratory assistants of the EIAR Ambo Plant Protection research Center. This training visit was coordinated by ARC-PPRI. Attendance was sponsored by South Africa (DWAF Working for Water Programme and Rhodes University)	2	1	1	Ethiopian research assistants to South Africa
Short-term Training	March 2009	A four day practical training course on quarantine facility management, plant nursery establishment, mass production, and safety testing procedures of introduced bio-agent. Attended by Dr. Ibrahim Fitiwy from Mekelle University, a partner of the parthenium project. The training was located at the Ambo plant protection	1	1	0	IPM CRSP parthenium partner from Mekelle University

		research center quarantine facilities.				
Short-term Training	12-28 January 2009	Training on the biological control of plant pests. Organized by Haramaya University Departmetn of Plant Sciences. Attended by Dr. Mulugeta Negeri from Ambo Plant Protection Research Center of EIAR gave lectures on biological control of parthenium weed in Ethiopia: the process, progresses and future plans, including concepts and procedures.	18	Unknown	Unknown	Dr. Mulugeta Negeri from Ambo Plant Protection research Center EIAR and 17 MS stundents of plant protection from Ambo University College
Workshop	Feb. 2009	Two day workshop at the parthenium and common bio-control laboratories where MS students from Haramaya Univeristy learned general principles and procedures of weed bio-control.	6	Unknown	Unknown	MS students in plant protection studies from Haramya University
Short-term Training	2009	General bio-control, parthenium bio-control progress and palnt protection research directions training for plant science diploma graduate assigned as development agents at Toke-Kutaye district. Trainging was held at the Ambo quarantine laboratory.	4	Unknown	Unknown	Plant science diploma graduates/development agents at Toke-Kutaye district
Meetings	October 2008	Technical discussions regarding facilities and biocontrol research activities were held between EIAR staff, L. Strathie, and A. McConnachie during their visit to Ethiopia and EIAR Ambo research station.	Unknown	Unknown	Unknown	EIAR staff, L. Strathie and A. McConnachie
Short-term Training	Jan-Feb 2009	Experiential weed biocontrol traingin at the Cegara Research Station as part of a Departmetn fo Water Affaris and forestry S Working for Water Capacity Building programme at the University of KwaZulu-Natal.	2	1	1	Attended by Ms. P. Dlamini and Mr. T. Dlamini
Short-term Training	2009	Short-term Training on the biological control fo parthenium lasting 2-5 days. The trainees came from Haramaya University, Harar Agro-technical College, Jimma University, Mekelle University, and from the Ministry of Agriculture and Rural Development.	49	42	7	Graduate and undergraduate students, researchers and extension workers
Farmer Training	2009	Farmer training on the health impacts of parthenium and its managemtn. During the “advisory gathering” poseters were prepared in Oromiffa, Somali, Tigrigna, and Amharic languages to explain the health impacts of parthenium and its management in the Jijiga area, Hirna, and the Dawro Zone.	43	31	12	Farmers of the Jijiga area, Hirna and the Dawro Zone
Meeting	17 October 2008	A quarantine facility inspection and discussion was held at the Ethiopian Insitute of Agricultural Research (EIAR) facilities at Ambo. Recommendations regarding the modifications to the extended quarantine facility were discussed.	4	Unknown	Unknown	L. Strathie, A. McConnachie, Dr. Negari and Dr. Zewdie.

Meeting	18-21 October	L. Strathie, A. McConnachie, and Steve Adkins visited the northern Tigray region of Ethiopia to view the facilities at Mekelle University, parthenium infestations and to select possible suitable areas for implementation of biological control and mass-rearing of *Zygogramma bicolorata*.	4	Unknown	Unknown	L. Strathie, A. McConnachie, S. Adkins and Fitiwy Beyan.
Meeting	31 Aug. 2009	Wondi Mersie and Eddie Moore, President of Virginia State University visited the Ambo Plant Quarnatine Facilitey and Mekelle University in northern Ethiopia. Eddie Moore signed an MOU with Mekelle University to cooperate in research and teaching.	Unknown	Unknown	Unknown	Wondi Mersie, Eddie Moore and Ethiopian collaborators
Short-term Training	2008-2009	Short-term training on weed biological control and quarantine procedures at the Ambo Plant Protection Research Center	75	64	11	Scientists and weed control specialists
Total Participants for the Parthenium Project – Global Theme Program			**1093**	**663**	**358**	

Program Type	**Date**	**Training Type**	**Number of participants**	**Men**	**Women**	**Audience**
IPDN – Global Theme Program						
Workshop (2)	2009	Week-long regional diagnostic training programs were conducted in West Africa (Bamako and Samanko, Mali, in cooperation with IER) and Central America. (The West Africa portion was funded by FAS)	45	29	16	Professionals from both West Africa and Central America
Workshop	2009	A two day diagnostic training workshop was held in Bishkek, Kyrgyzstan in cooperation with IPM CRSP central asia.	Unknown	Unknown	Unknown	Professionals
Workshop	2009	A training workshop was given on the identification of plant pathogens including bacteria, virus, nematodes and fungi and special sessions on entomology.	35	Unknown	Unknown	Professionals from Guatemala, El Salvador, Honduras and Jamaica
Meeting	2009	The third Central American IPDN Diagnostic Meeting was held in Guatemala City at Universidad Rafael Landivar. This was the first regional training program within IPDN conducted solely by local resource persons.	Unknown	Unknown	Unknown	Professionals
Workshop	17-18 Sept 2009	The third Central American IPDN Diagnostic Workshop was held in Guatemala City. Mycology, nematology, bacteriology and virology sessions were conducted at the Universidad Rafael Landivar (URL)	20	13	7	Diagnosticians from Guatemala, Honduras and El Salvador attended representing all institutions and labs working in plant disease diagnostics.
Training	Sept 2009	A session in bacteriology was conducted by Dr. Marco Arevalo from Agroexpertos and Dr. Edin Orozco a plant	20	13	7	Professionals

		pathologist from San Carlos University. This session was part of the 3rd Central American IPDN Diagnostic Workshop 2009				
Training	Sept 2009	A session in mycology was conducted by Dr. José Melgar from FHIA. Honduras. This session was part of the 3rd Central American IPDN Diagnostic Workshop 2009	20	13	7	Professionals
Training	Sept 2009	A session in nematology was conducted by Dr. Javier Diaz from FHIA, Honduras. This session was part of the 3rd Central American IPDN Diagnostic Workshop 2009	20	13	7	Professionals
Training	Sept 2009	A session in virology was conducted by Dr. Margarita Palmieri from UVG. This session was part of the 3rd Central American IPDN Diagnostic Workshop 2009	20	13	7	Professionals
Training	Sept 2009	A session on DDIS was conducted by Dr. Mark Arevalo from Agroexpertos. This session was a part of the 3rd Central American IPDN Diagnostic Workshop 2009.	20	13	7	Professionals
Training	Sept 2009	A session on SOP was conducted by Dr. Mark Arevalo from Agroexpertos. This session was a part of the 3rd Central American IPDN Diagnostic Workshop 2009.	20	13	7	Professionals
Other	2009	Workshop grant proposal submitted by Dr. Paula Agudelo (Clemson University) APS-OIP Global Experience Plant-Parasitic Nematode Identification Workshop.	1	Unknown	Unknown	Professional
Workshop	2009	A 2-day diagnostics training workshop in Bishkek, Kyrgyzstan was conducted in June by Dr. Sally Miller, Dr. George Bird, Dr. Barry Jacobsen, Dr. Dough Landis, Dr. Frank Zalom and Dr. Mustafa Bohssini, ICARDA.	Unknown	Unknown	Unknown	Professionals
Total participants in the IPDN – Global Theme Program			**221**	**120**	**65**	

Program Type	Date	Training Type	Number of participants	Men	Women	Audience
Thrips-borne Tospoviruses – Global Theme						
Farmer Field Day		Farmers Field day near Dharmapuri, Tamil Nadu, India, August 21, 2009. Naidu Rayapati and Karthikeyan Gandhi	Unknown	Unknown	Unknown	Farmers
Farmer Field Day		Field Day in Udumalpet taluk of Tiruppur district in Tamil Nadu, India. Karthikeyan Gandhi. 2009.	Unknown	Unknown	Unknown	Farmers
Training Course		"Diagnosis of Plant Virus Diseases" in collaboration with Dr. P. Lava Kumar, Virologist at IITA, Ibadan, Nigeria, during April 28 – May 10, 2009.	22	14	8	PhD students, scientists and extension workers, from 12 countries in Sub-Saharan Africa attended the training course
Farmer Meetings		Visits to fields and vegetable markets by Naidu Rayapati,	173	115	58	Producers and Sellers

		Karthikeyan Gandhi and Kodetham Gopinath 2008-2009				
Field Day		Field Day in Udumalpet taluk of Tiruppur district in Tamil Nadu, India	17	5	12	Farmers
Field Day		Farmers Field day near Dharmapuri, Tamil Nadu, India, August 21, 2009, Naidu Rayapati and Karthikeyan Gandhi	63	43	20	Farmers
National Training Course		Detection of seed borne viruses. Training course for seed testing officers, national seed research and training institute, Varanasi, UP India July 13-17, 2009	40	28	12	Seed Testing Officers
Meeting		International partnerships: Why it matters for Africa? International Institute of Tropical Agriculture, Lagos, Nigeria May 8, 2009	22	14	8	Agricultural professionals
Symposium		Reconstruction of Brome Mosaic Virus infection through RNA trafficking and the role fo two yeast cellular proteins on RNA transport. The trends in plant biology mini symposium at the Indian institute of education and research institute pune india august 8 2009	75	15	60	Biology professionals
Training		Dealing with complex virus disease problems-a case of tospovirus disease in vegetables. Departmetn of plant molecular biology and biotechnology center for plant molecular biology Tamil Nadu agricultural university Coimbatore, India, August 20, 2009. Naidu Rayapati	67	37	30	Biology professionals
Training		Thrips-borne tospoviruses and their management and how the IPM CRSP funded project is generating knowledge that could be used to develop IPM tactics for the management of PBNV. Department of plant pathology center for plant protection studies, tamil nadu agricultural university, Coimbatore, india, August 19, 2009	60	33	27	
Seminar		Screening of yeast proteome and the role of cellular proteins on Brome mosaic virus RNA replication, systemic movement and long distance RNA trafficking. International seminar on Plant Biotechnology and Genomics Towards and New Green Revolution (ISPBG2009) Kadapa, Andhra Pradech, India, and Kodetham Gopinath Februrary 6-7, 2009	150	95	55	
Other	2009	Farmers, farm workers and commercial nurseries were assisted with tospovirus and other virus diseases and their management in vegetables in Tamil Nadu and Andhra Pradesh in India.	253	170	83	Farmers, farm workers and commercial nurseries
Other	2009	Students and faculty benefited from the science-based knowledge generated from IPM CRSP projects	135	90	45	Graduate Students and Faculty/Scientists
Training	March 2009	A training session on IPM strategies for the management	30	23	7	Scientists

		of insect transmitted plant virus diseases was held at the 6th International Symposium-Transcending boundaries				
Symposium	Sept. 2009	The IX International symposium on Thysanoptera and Tospoviruses was held at Sea World Resort, Gold Coast, Queensland, Australia from August 31 to Sept. 4 2009	87	49	38	Scientists and Students
Short-term Training	Sept 2008 to April 2009	Dr. N. Balakrishnan, faculty member from Tamil Nadu Ag. University (TNAU) attended short-term trianing on thrips and tospoviruses at Washington State University under the direction of Dr. Rayapati.	1	1	0	Scientist
Short-term Training	Jan-Feb 2009	Dr. S.K. Manoranjitham, assistant professor, Department of Fruit Crops, Horticultural College and research Institute, TNAU, Coimbatore, attended hands-on experience in molecular diagnosis of vegetable viruses in Dr. Rayapati's lab. Her training was supported by a human resource development project funded through the Indian Council of Ag. Research for faculty capacity building in advanced ag sciences at TNAU.	1	0	1	Scientist
Short-term Training	March-April 2009	Dr. Margarita Palmieri, of the Universidad del Valle De Guatemala, Guatemala, attended short-term training on techniques related to the diagnosis of plant viruses in vegetables in Dr. Rayapati's laboratory. Her trainging was funded by her department.	1	0	1	Scientist
Total Participants for Thrips-borne Tospoviruses- Global program			**1197**	**732**	**465**	

Program Type	**Date**	**Training Type**	**Number of participants**	**Men**	**Women**	**Audience**
Insect Transmitted Viruses – Global Theme						
Farmer Field Day/Workshop	27 May 2009	A farmer field day was held in Jamaica 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.	18	11	7	Pepper farmers from St. Catherine and Clarendon, extension officers from the local Rural Ag. Development Authority and the local Ag. Support Services Project
Seminar	27 May 2009	A tobacco etch virus (TEV) in Scotch Bonnet pepper seminar was presented in Jamaica.	18	11	7	Pepper farmers from St. Catherine and Clarendon, extension officers from the local Rural Ag. Dev. Authority and the local Ag Support Services Project
Workshop	2009	Small periodic workshops were given to growers and field	Unknown	Unknown	Unknown	Growers and field technicians

		technicians to emphasize the importance of IPM strategies for the management of begomoviral infections. The workshop was held in Guatemala and organized by the field supervisor for the whitefly and begomovirus monitoring program.				
Workshop	2009	Demonstrations of PCR for detection of begomoviruses was held in Honduras as part of a broader collaboration held with AVRDC. It was facilitated by Dr. Wen-Shi Tsai	4	4	1	Professionals from FHIA-Plant Patholgy, UNA agronomy department, and Zamorano-Plant Protection
Workshop	2009	A hands-on workshop in Honduras at FHIA's plant pathology laboratory to demonstrate the procedure folloed in AVRDC for detection of Begomoviruses utilizing PCR.	4	4	1	Professionals from FHIA-Plant Patholgy, UNA agronomy department, and Zamorano-Plant Protection
Meeting	2009	Sue Tolin met with collaborators from Zamorano University and FHIA to observe and collect samples of pepper and tomato plats showing virus-like symptoms.	5	Unknown	Unknown	Sue Tolin, Maria Mercedes Roca, Mauricio Riveiera and two laboratory assistants
Demonstration	2009	Sue Tolin gave demonstrations in Honduras of tissue blot immunoassays and immunostrip assays, applied for certain RNA viruses. Participants were also trained for select and packaging samples to be sent to Agdia, Inc. for extensive testing.	Unknown	Unknown	Unknown	Sue Tolin and researchers at Roca's lab at FHIA
Meeting	2009	Judy Brown visited Mauricio Rivera and Jose Melgar of FHIA in Honduras to observe potato crops in which symptoms reminiscent of viral disease have been showing up frequently the last four years. Samples of potato and psyllid were taken to Brown's laboratory to identify the presence of a bacterium. The findings will be considered in future collaborative research and technology transfer work.	3	2	1	Professionals
Meeting	2009	Sue Tolin and Mike Deom visited collaborator Teresa Martinez in the Domincan Republic to evaluate the new laboratory facilities and assist in equipment operations, placement, and management, and make recommendations on additional needs and design. Samples from pepper were collected from farmer's fields and experimental plots in Paya and the Ocoa Valley respectively.	3	1	2	Professionals
Training	2009	Tissue blot immunoassays were prepared in the Dominican Republic in the field and their development was conducted in the Martinez lab the next day. This training was conducted for martinez's two students.	3	Unknown	Unknown	Scientists/students
Training	2009	Martinez visited Sue Tolins lab for training on PCR	1	0	1	Scientist

		techniques using pepper samples TBIA membranes				
Meeting	2009	Collaborators in Africa meet in Cameroon in September to discuss capacity building to process samples and detect geminiviruses and their whitefly vector species and biotypes.	5	4	1	Leke from Cameroon, Koutou from Burkino Faso, James Legg from IITA, Judy Brown from Arizona, and Anders Kvarnheden from Sweden
Meeting	2009	IPM CRSP Global Theme leaders S. Tolin, N. Rayapati collaborated to submit a request for a special session on IPM Strategies for the Managemtn fo Insect-Transmitted Plant Virus Diseases at the Sixth Intl. IPM Symp held in Portland Oregon.	4	Unknown	Unknown	S. Tolin, N. Rayapati, M. Palmieri and another speaker
Short-term Training	2009	Ms. Yen-Wen Kuo, a PhD student in the Gilbertson lab at UC-Davis has continued to receive training with geminvirus characterization techniques.	1	0	1	PhD student at UC Davis
Short-term Training	2009	Tomas Guitierrez, a PhD student who is from Peru and working in the Gilbertson lab at UC-Davis is woring on detection and characterization of whitefly-transmitted begomoviruses from Latin America and East and West Africa and the development of IM packages for these virual disease.	1	1	0	PhD student at UC Davis
Short-term Training	2009	Mr. Mamadou Koutou, collaborator in Burkina Faso, received training on molecular tools at the Swedish University of Ag. Sciences (SLU) under the Rothamsted African Fellowship program. The sequencing and laboratory fees were supported by the scholarship, travel expenses, and stipend.	1	1	0	Mr. Mamadou Koutou from Burkina Faso
Short-term Training	2009	Mr. Arnoldo Font from the U. del Valle De Guatemala was sent for training in the Judy Brown lab at the University fo Arizona where he learned how to identify sewuences from whitefly species of the New and Old World.	1	1	0	Mr. Arnoldo Font from Guatemala
Workshop	2009	Monica Orozco and Claudia Toledo of the Palmieri lab at U. del Valle De Guatemala attended a workshop sponsored by the IPDN Global Theme at the Universidad Rafael Landivar.	2	0	2	Monica Orozco and Claudia Toledo from Guatemala
Presentation	2009	"Basics of Integrated Managemtn of Virus and Virus-like Diseases of Vegetable Crops" was presented in la Lima and Comayagua J. C. Melgar. The event was funded by USAID EDA and RED projects and the focus was general biology of viruses and their means of transmission as determinants of the strategies used for their integrated management.	52	40	3	Extension workers of MCA
Presentation	2009	"Reaction to virus diseases and effect of plastic mulch on	406	304	102	Scientists from 14 countries of

		virus incidence and severity of commercial tomato cultivars in the field." This presentation was a work session of the XI International Congress on IPM of the Mesoamerican Regionheld in Tegucigalpa Honduras.				the Mesoamerican and Caribbean region indlucing professional agriculturalists representing academina, private sector, governmental, private development agencies, undergraduate students from Zamorano Univeristy, etc.
Total Participants for the Insect Transmitted Viruses – Global Program			**532**	**384**	**129**	
Impact Assessment – Global Theme						
Symposium	2009	Multiple presentations were made during the Australian Agricultural and resorue Econmics Society, Cairns, Queensland, Australia.	Unknown	Unknown	Unknown	Professionals and students
Symposium	2009	Multiple presentations were made during the 6th International IPM symposium in Portland Oregon at the American Agricultural Economics Association Meeting.	Unknown	Unknown	Unknown	Professionals and students
Total Participants in the Impact Assessment – Global Theme Program			**Unknown**	**Unknown**	**Unknown**	
TOTAL PARTICIPANTS FOR IPM CRSP ACTIVITIES			**91483**	**5519**	**2332**	

Table 7: IPM CRSP Publications, Presentations, Posters and Abstracts (Summary)

	Publications	Presentations	Posters	Abstracts	Total
Regional Programs					
Latin America and Caribbean - Regional Program	24	18	0	0	**42**
East Africa – Regional Program	23 (*5)	13	8	5	**49**
West Africa – Regional Program	88	0	0	0	**88**
South Asia – Regional Programs	6 (*1)	1	1	0	**8**
Southeast Asia – Regional Program	19	8	1	0	**28**
Central Asia – Regional Program	13	19	0	0	**32**
Eastern Europe – Regional Program	1	2	11	0	**14**
Global Programs					
Parthenium Project – Global Program	10	0	0	0	**10**
IPDN – Global Theme Program	8	4	1	0	**13**
Thrips-borne Tospoviruses – Global Program	11	14	0	0	**25**
Insect Transmitted Viruses – Global Theme Program	16 (*7)	9	1	0	**26**
Impact Assessment – Global Theme Program	0	0	0	0	**0**
Applications of Information Technology and Databases in IPM in Developing Countries and Development of a Global IPM Technology Database	0	0	0	0	**0**
IPM CRSP Management Entity	20	6	5	0	**37**
***submitted for publication**					
Total	**239**	**94**	**28**	**5**	**366**

IPM CRSP Publications, Presentations, and other Products, FY2009

Latin American and the Caribbean

Publications:

Mazariegos, L.M. and V. Mérida. 2008. "La incorporación de manejo integrado de plagas en un centro nufed de ciclo básico del nivel medio de Guatemala: Generación de lecciones aprendidas para transferencia a IPM-CRSP Honduras. Informe final consolidado presentado por Luisa María Mazariegos y Verónica Mérida, Estudio 1360/IPM-CRSP Guatemala, a Dr. Sarah Hamilton, IPM CRSP-Honduras/Virginia Tech/Denver University." December 2008. The final report was submitted to FHIA, the Guatemalan Ministry of Education, and Virginia Tech:

Hamilton, S. 2008. La incorporación de manejo integrado de plagas en un centro nufed de ciclo básico del nivel medio de Guatemala: Generación de lecciones aprendidas para transferencia a IPM-CRSP Honduras. Informe final consolidado presentado por Luisa María Mazariegos y Verónica Mérida, Estudio 1360/IPM-CRSP Guatemala, a Dra. Sarah Hamilton, IPM CRSP-Honduras/Virginia Tech/Denver University." December 2008.

Hamilton, S. 2008. La importancia de la temática de género en el manejo integrado de plagas y la agricultura sostenible. Proceedings of the XI International Integrated Pest Management Congress, Tegucigalpa, Honduras, October 2008

Hamilton, S., V. Mérida and L.M. Mazariegos. 2008. Incorporación de MIP en una escuela rural de Guatemala: Lecciones aprendidas para transferencia en Centroamérica. Proceedings of the XI International Integrated Pest Management Congress, Tegucigalpa, Honduras, October 2008

FHIA. 2009. "Manejo Seguro de Plaguicidas Agrícolas" (Safe Use of Agricultural Pesticides), a 60-page, full color graphically illustrated manual. Produced by FHIA, Honduras. It covers in a simple way the concept, history and importance of pests; strategies for pest management; the history, status, profile and mode of action of the pesticides, as well as the ways of penetration into the human body; interpretation of label, types of containers, protection equipment, preparation of mixes, management of spills, handling of used containers, cleaning-up application equipment; handling of intoxications; basic principles for selection and correct application of pesticides; and tables with the principal chemical groups of insecticides, acaricidas, fungicides and herbicides.

Buck, S. and J. Alwang. 2009. "The Impact of Trust on Farmer Learning: Results from Economic Experiments in Ecuador", World Development, in press.

Asaquibay, C., P.M. Gallegos, R. Williams and J. Alwang. 2009. Comportamiento y Alternativas de control de gusano del fruto de la naranjilla (*Neoleucinodes elegantalis*). Quito, EC, EC, INIAP, Dpto. Protección Vegetal, Est. Exp. Santa Catalina, Quito, Ecuador. 16p. (Boletín Divulgativo no. 347).

Vera, D.I., Suárez-Capello and P.A. Backman.2008 Evaluation of Sigatoka Disease Severity in plantain under five spatial arrangement. Cocoa/plantain intercropping system. Plant Disease Management Report, 2007-8.

Vera, D.I., Suárez-Capello and P.A. Backman. 2008. Evaluation of Witches broom disease in cação for cação/plantain intercropping systems under five spatial arrangements, Plant Disease Management Report, 2008.

Ochoa, J. and M. Ellis presented complementary pest management programs developed so far for naranjilla in the Congress of the Latin American Phytopathological Society (ALF) in Santiago-Chile in January 2009; the corresponding article was awarded a recognition from the Spanish Phytopathological Society (AEF).

Pazmiño, G. 2008. Comportamiento de la sección Lasiocarpa del género *Solanum* a la patogenicidad de *Phytophthora infestans* en Ecuador. Tesis Ing. Agr. Quito, Ec, Universidad Central del Ecuador, Facultad de Ciencias Agrícolas. 184 p.

Arcos, D. 2008. Validación de control del Barrenador del fruto de naranjilla *Neoleucinodes elegantalis*. En naranjilla S. quitoense Lam. En San francisco Mira provincia del Carchi. Tesis Ing. Agr. Quito, Ec. EC, Universidad Central del Ecuador, Facultad de Ciencias Agrícolas. 120p.

Clavijo F. 2008. Evaluación de la reacción de segregantes interespecíficos de la naranjilla (*Solanum quitoense* Lam.) a los agentes fitopatógenos (F*usarium oxysporum*) y (P*hytophthora infestans*). Tesis Ing. Agr. Latacunga, Ec, Universidad Técnica de Cotopaxi, Facultad de ciencias Agronómicas, Ambientales y Veterinarias. 104p.

Jarrín, J. 2009. Aspectos epidemiológicos y de control químico de antracnosis (*Colletotrichum gloesporioides)* en naranjilla (*Solanum quitoense* Lam).Tesis Ing. Agr. Quito, Ec., Escuela Politécnica del Ejercito. 80 p.

Manangón, L. 2009 Patogenicidad de *Fusarium oxysporum* f.sp *quitoense* en la Sección Lasiocarpa. Tesis Ing. Agr. Quito, Ec., Escuela Politécnica del Ejercito. 87 p.

Flowers, R.W. and C.S. Chaboo. 2009. Novel host records of some cassidine leaf beetles from Ecuador (Coleoptera: Chrysomelidae: Cassidinae) Date of Issue: September 25, 2009 INSECTA MUNDI A Journal of World Insect Systematics 0095

Melnick, R.L. Suárez-Capello, B.A. Bailey, K. Solis and P.A. Backman. 2009. Impact of application of endophytic *Bacillus* spp. for biocontrol of cacao diseases on native microbial communities. APS Annual Meeting abstract Phytopathology 100: (In Press)

Melnick, R.L., Suárez-Capello, B.A. Bailey, D.I. Vera, K. Solis and P.A. Backman. 2009. Biological control of *Theobroma cacao* pod diseases with endophytic *Bacillus* spp. APS Annual Meeting abstract Phytopathology 100(In Press)

Melnick, R.L., B.A. Bailey, M.D. Strem and P.A. Backman. 2009. Ability of endophytic *Bacillus* spp. to activate plant defense genes of *Theobroma cacao*. APS Potomac Division Meeting Abstract. Phytopathology 99 S203.

Bae, H., D.P. Roberts, H.S. Lim, M.D. Strem, S.C. Park, C.H. Ryu, R.L. Melnick and B.A. Bailey. 2009. *Trichoderma* isolates from tropical environments induce resistance against *Phytophthora capsici* in Korean hot pepper. APS Potomac Division Meeting Abstract. Phytopathology 99 S203.

Bae, H., R.C. Sicher, M.S. Kim, S.H. Kim, M.D. Strem, R.L. Melnick, and B.A. Bailey. 2009. The beneficial endophyte, *Trichoderma hamatum* isolate DIS 219b, promotes growth and delays the onset of the drought response in *Theobroma cacao*. Journal of Experimental Botany 60(11): 3279-3295.

Flowers, R.W. 2009. A second species of Apterodina (Chrysomelidae: Eumolpinae) from Ecuador R. WILLS FLOWERS, Zootaxa 2131: 65–68 (2009)

Flowers, R.W. 2009. Addressing the Taxonomic Impediment in western Ecuador R. Wills Flowers. EDIT Newsletter 13, February 2009. http://www.e-taxonomy.eu

Flowers, R.W. 2009. A new genus and species of Eumolpinae (Coleoptera: Chrysomelidae) from the western dry forest of Ecuador Zootaxa 2132: 65–68 (2009)

Presentations

Díaz, F.J. and S. Weller. 2009. Evaluation of the reaction to the root knot nematode (*Meloidogyne* spp) of varieties of Cowpea [*Vigna unguiculata* (L.)] used as a rotation crop in horticultural soils. XI International Congress of the Mesoamerican region on Integrated Pest Management, held in Tegucigalpa

Durán, L.F., F.J. Díaz, J.M. Rivera C. and S. Weller. 2009. Effect of the orientation, number, and nozzle type on the chemical control of onion thrips, *Thrips tabaci* in onions. XI International Congress of the Mesoamerican region on Integrated Pest Management, held in Tegucigalpa

Melgar, J.C., F.J. Díaz and S. Weller. 2009. Solarization of seed germination substrates and soil of field production plots for control of soil borne pests and diseases. XI International Congress of the Mesoamerican region on Integrated Pest Management, held in Tegucigalpa

Espinoza, H.R. and S. Weller. 2009. Release of predatory mites for the control of phytophagous mites in Chinese eggplant. XI International Congress of the Mesoamerican region on Integrated Pest Management, held in Tegucigalpa

Espinoza, H.R.and S. Weller. 2009. Release of predatory mites for the control of phytophagous mites in strawberry. XI International Congress of the Mesoamerican region on Integrated Pest Management, held in Tegucigalpa

Espinoza, H.R. and S. Weller. 2009. Efficacy of hot water treatment for the control of the strawberry mite in strawberry planting material. XI International Congress of the Mesoamerican region on Integrated Pest Management, held in Tegucigalpa

Hamilton, S. 2009. "Markets, Poverty, and the Environment in Central America: Policy recommendations based on socioeconomic studies from the IPM CRSP in Guatemala and Honduras. Presented at the University of Denver, Faculty Research Seminar Series, May 2009.

Backman, P., B. Bayley and R. Collins. 2009. A short seminar about "Introduction to Endophytes-Endophitic Interactions between *Trichoderm*a spp, *Bacillus* spp and cacao in Pichilingue for facilitators, teacher, scientists and students.

Flowers, W. 2009. Training on insects and arthropods identification to INIAP and AGROCALIDAD staff and has given short courses on this topic for the above and local Universities (Army Politectic, UTEQ) which is improving the status of the entomological science in the country.

Melnick, R. 2009. Biological control of cacao diseases using native *Bacillus* spp. USAID IPM-CRSP Meeting on Integrated Pest Management, Part of INIAP 50th Anniversary Seminar Series. INIAP Tropical Research Station, Pichilingue, Los Rios, Ecuador.

Backman, P. 2009. IPM/Biological Control and Endophytes—how can we provide sustainable alternatives to pesticides? January 2009. USAID IPM-CRSP Meeting on Integrated Pest Management, Part of INIAP 50th Anniversary Seminar Series. INIAP Tropical Research Station, Pichilingue, Los Rios, Ecuador.

Guiltinan, M. 2009. USAID IPM-CRSP Meeting on Integrated Pest Management, Part of INIAP 50th Anniversary Seminar Series. INIAP Tropical Research Station, Pichilingue, Los Rios, Ecuador.

Maximova, S. 2009. Field Evaluation of Cacao Somatic Embryo-derived Plants and Molecular Basis of Fungal Endophyte/Host Interactions in Theobroma cacao. January 2009. USAID IPM-CRSP Meeting on Integrated Pest Management, Part of INIAP 50th Anniversary Seminar Series. INIAP Tropical Research Station, Pichilingue, Los Rios, Ecuador.

Melnick, R. and P.A. Backman. 2009. Impact of application of endophytic *Bacillus* spp. for biocontrol of cacao diseases on native microbial communities. August 2009. American Phytopathological Society Annual Meeting. Portland, OR.

Melnick, R. and P.A. Backman. 2009. Ability of endophytic *Bacillus* spp. to activate plant defense genes of *Theobroma cacao*. March 2009. American Phytopathological Society Potomac Division Meeting. Gettysburg, PA.

Andrade, R., J. Alwang, G.W. Norton and V. Barrera 2009. Livelihood strategies and economic well-being in Bolivar, Ecuador. How to improve economic assessment of IPM. Presented at the International IPM Symposium, Portland, March 24. 2009.

Ochoa, J., P. Gallegos, C. Asaquibay, J. Alwang and V. Barrera. 2009. "IPM CRSP: Socializacion de Resultados." Seminar to INIAP Staff May 25, 2009. Santa Catalina, Ecuador

Ochoa, J., P. Gallegos, C. Asaquibay, J. Alwang and V. Barrera. 2009. "IPM CRSP: Socializacion de Resultados."Seminar to INIAP Staff May 25, 2009. Santa Catalina, Ecuador

East Africa

Publications:

Amata, R. L., M.J. Otipa, M. Wabule, E.G. Thuranira, M. Erbaugh, and S. Miller. 2009. Incidence, prevalence and severity of passion fruit fungal diseases in Kenya. Journal of Applied Biosciences, **20:** 1146-1152.

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*, Vol. 99, No.5: 540-547.

Hristovska, Tatjana, 2009. Economic Impacts of Integrated pest Management in Developing Countries: Evidence from the IPM CRSP. Unpublished Masters Thesis. Virginia Tech University

Miller, S.A., Z.M. Kinyua, F. Beed, C.L. Harmon, J. Xin, P. Vergot, T. Momol, R. Gilbertson and L. Garcia. 2009. The International Plant Diagnostic Network (IPDN) in Africa: Improving capacity for diagnosing diseases of banana and other African crops. ActaHort. (in press).

Lewis Ivey, M. L., Tusiime, G. and Miller, S. A. 2009. A PCR assay for the detection of Xanthomonas campestris pv. musacearum in bananas. Plant Disease 93 (in press).

Carter, B. A., R. Reeder, S.R. Mgenzi, Z.M. Kinyua, J.N. Mbaka, K. Doyle, M. Maina, G. Valentine, V. Aritua, M.L. Lewis Ivey, S.A. Miller and J.J. Smith. 2009. First report of Xanthomonas campestris pv. musacearum, causative organism of banana xanthomonas wilt, in Tanzania, Burundi and Kenya. New Disease Reports 19 http://www.bspp.org.uk/publications/new-disease-reports/ndr.php?id=019025 .

Abstracts

Kuria S.N, J.M. Kibaki, A.M. Ndegwa, M.M. Waiganjo and R.G. Munene. 2008. Evaluation of Advanced Tomato Breeding Lines for Resistance to Bactrial Wilt (*Ralstonia solanacearum)* 8th Workshop on Sustainable Horticultural Production in the Tropics. Masinde Muliro University of Science and Technology (MMUST), Kakamega, 8th-11th December 2008. *Book of Abstract p.34*

Kuria S.N, M.M.Waiganjo, B.M. Ngari, S.B. Wepukhulu, M. Erbaugh, J. Kovach and D. Taylor. 2009. Comparative Performance of Introduced Hybrid Tomato Varieties and Locally Bred

Tomato Lines against Bacterial Wilt (*Ralstonia solanacearum*) and Root Knot Nematodes at Mwea in Kenya. All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya. *Book of Abstract p.*

Mbaka J, L. Wasilwa and M. Maina. 2009. Banana for food, income and Nutrition Security: the role of macro and micro propagation in Kenya. Poster presented at All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya. *Book of Abstract p.*

Mbaka, J.N., M.M. Waiganjo and Z. Kinyua. 2008. Creation of awareness on banana Xanthomonas wilt (*Xanthomonas campestris* pv *musacearum*) in Kenya. Poster presented during the 8th Workshop on Sustainable Horticultural Production in the Tropics held at Masinde Muliro University of Science and Technology (MMUST), KAKAMEGA December 8th-11th 2008. *Book of Abstract p.42*

Waiganjo M.M., C.N. Waturu, J.K. Njuguna G.W. Mbugua and L. Gitonga. 2008. Banana Production Challenges and Some Research Interventions Undertaken By KARI-Horticultural Program Under The USAID-SO7 Project. Poster presented during the International Conference on Banana and Plantain: Harnessing international partnerships to increase research impact' held at Leisure Lodge Resort Mombasa Kenya 5-9th October, 2008. *Book of Abstract p.143-144*

Publication Submissions

Waiganjo M.M, I. Onyango, S.N. Kuria, S.B. Wepukhulu, M.N. Wabule, M. Erbaugh and J. Kovach. 2008. Environmentally Safe and Cost Effective Tomato Pest Management Options For Small Holder Growers At Thika, Kenya. Paper submitted for publication in the *African Journal of Horticultural Science*

Karungi, J., P. Agamire , J. Kovach and S. Kyamanywa. Cover cropping and novel pesticide usage in the management of pests of hot pepper (*Solanum chinense*) to the International Journal of Tropical Science for publication where it is under review.

Otim, Michael. Farmers' perceptions, incidence and management of tomato fruitworm, *Helicoverpa armigera* in Central Uganda. Submitted to International Journal of Tropical Science.

Ochwo-Ssemakula M., V. Aritua, T. Sengooba, J.J. Hakiza, E. Adipala, R. Edema, P. Redinbaugh and S. Winter. The potyvirus infecting cultivated and wild passion fruit in Uganda is a distinctive virus species. *Manuscript submitted for publication* in Plant Disease Journal.

Maerere, A.P., K.P. Sibuga, J.E.M. Bulali, M.W. Mwatawala, J. Kovach, S. Kyamanywa and M. Erbaugh. (2009). Deriving Appropriate Pest Management Technologies for Smallholder Tomato (*Solanum lycopersicum* Mill.) Growers: A Case Study of Morogoro, Tanzania.

Posters

Kyamanywa S., P. Kucel, N. Uringi J. Kovach, A. Roberts, and M. Erbaugh. 2009. Arabica coffee pest profiles in the Mount Elgon area of Uganda. A poster presented at the 6th International IPM Symposium, March 24 – 26, 2009, Portland, Oregon USA. The presented poster is appended on the www.ipmcenters.org/ipmsymposium09/abstracts.cfm.

Karungi, J., P. Agamile, E. Muhumuza, J. Kovach, E.N. Sabiiti, M. Erbaugh and S. Kyamanywa. 2009. Effect of intercropping and a bio-pesticide on population dynamics of two aphid species Brevocoryne brassicae and Aphis gossypi. A poster presented at the 6th International IPM Symposium, March 24 – 26, 2009, Portland, Oregon USA.

Waiganjo M.M, B.M. Ngari, S.B. Wepukhulu, S.N. Kuria, M.N. Wabule, M. Erbaugh, J. Kovach and D. Taylor. 2009. Ascertaining survey information through Biological Monitoring: A case study of Tomato pest management practices in Kirinyaga District, Kenya. A poster presented at All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya.

Otipa, M. J, R.L. Amata, M. Waiganjo, J.G. Mureithi, L. Wasilwa, L. Ateka, E. Mamati, D. Miano, J. Kinoti, S. Kyamanywa, M. Erbaugh and S. Miller. 2009. Challenges facing Passion fruit Smallholder Pro Poor farmers in North Rift Region of Kenya**.** A poster presented at All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya.

Kuria S.N, J.M. Kibaki, A.M. Ndegwa, M.M. Waiganjo and R.G. Munene. 2008. Evaluation of Advanced Tomato Breeding Lines for Resistance to Bactrial Wilt (*Ralstonia solanacearum)* A Poster presented during the 8th Workshop on Sustainable Horticultural Production in the Tropics. Masinde Muliro University of Science and Technology (MMUST), Kakamega, 8th-11th December 2008.

Mbaka J, L. Wasilwa and M. Maina. 2009. Banana for food, income and Nutrition Security: the role of macro and micro propagation in Kenya. Poster presented at All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya. *Book of Abstract p.*

Mbaka, J.N., M.M. Waiganjo and Z. Kinyua. 2008. Creation of awareness on banana Xanthomonas wilt (*Xanthomonas campestris* pv *musacearum*) in Kenya.
Poster presented during the 8th Workshop on Sustainable Horticultural Production in the Tropics held at Masinde Muliro University of Science and Technology (MMUST), KAKAMEGA December 8th-11th 2008. *Book of Abstract p.42*

Waiganjo M.M., C.N. Waturu, J.K. Njuguna G.W. Mbugua. and L. Gitonga. 2008. Banana Production Challenges and Some Research Interventions Undertaken By KARI-Horticultural Program Under The USAID-SO7 Project. Poster presented during the International Conference on Banana and Plantain: Harnessing international partnerships to increase research impact' held at Leisure Lodge Resort Mombasa Kenya 5-9th October, 2008. *Book of Abstracts p.143-144*

Popular Press

Poem - The Impact of the Tomato IPM CRSP Training Programme in Busukuma Sub-county – composed by Joseph Kitonsa; translated by Dr. Robinah Ssonko; recited by tomato grower at the Open Field day (25th June, 2009)

Success story of Mr. Matthew Ssekabembe, a participant of the Tomato IPM Programme in Busukuma Sub-county (compiled by Mark Erbaugh and Zachary Muwanga) presented for publication on the IPM CRSP Website (June, 2009) .

Kenya: Newspaper cuttings: IPM CRSP Passionfruit activities-Newspaper cutting 7th Dec. 2008-Sunday Nation newspaper.

USAID Fact Sheet: Increasing Farmer's Income in Uganda
www.usaid.gov/press/factsheets/2009/fs091019

International IPM program a Success for Tomato Producers in Africa
http://oia.osu.edu/news-releases/1036-international-ipm-program-a-success-for-tomato

IPMnet – July/August 2009 IPMnet News,
VI. U.S. AID's IPM-Collaborative Research Support Program, IPM Approach Benefits Ugandan Tomato Crops

Extension publications

Brochure on "Management of key insect pests of Arabica coffee in Uganda" completed;

Brochure on "Management of coffee lace bugs (*Habrochila spp*.) on Arabica coffee in Uganda" completed;

A draft Research Guide has been made. It is entitled "Procedures of *in-planta* detection of *Xanthomonas campestris* pv. *musacearum* in banana: A Research Guide".

Tanzania: Extension leaflets on use and application of mulch in tomato production have been drafted. A total of 109 (81 males and 28 females) farmers and extension officers were provided with the leaflets and posters.

Titles: (1) Matumizi ya Matandazo kwenye Kilimo cha Nyanya (Use of Mulch in Tomato Cultivation); (2) Magonjwa ya Nyanya Morogoro (Common TOMATO Diseases in Morogoro)

Tanzania: Disseminate Arabica coffee IPM technologies to TaCRI farmer groups. 12,000 leaflets and 1000 posters were produced and used for training. They were on safe handling of pesticides, pest identification, use of botanicals and IPM approaches to pest management.

Presentations

Amata, R.L., M.J. Otipa, M. Wabule, J. Kinoti, S. Kyamanwa, M. Erbaugh and S. Miller. 2008. Dieback disease, devastating passion fruit production in Kenya. Presented at the 11thKARI Biennual Conference. KARI headquarters, 10-14th November 2008.

Amata, R.L., M.J. Otipa, M. Waiganjo, L. Wasilwa, J. Kinoti, S. Kyamanwa and M. Erbaugh. 2009. Passion fruit production systems management strategies for fungal diseases in Kenya. Presented at the All Africa Horticulture Congress, Safari Park Hotel Nairobi, 31st August to 3rd September 2009, Nairobi, Kenya.

Kahinga J.N, C.N. Waturu, S.B. Wepukhulu, J.K. Njuguna, M.M. Waiganjo and P.N. Mugii. 2008. Higher Yielding Passionfruit Cultivars Can Revolutionize The Industry in Kenya. Presented during the 8th Workshop on Sustainable Horticultural Production in the Tropics held at Masinde Muliro University of Science and Technology (MMUST), Kakamega December 8th-11th 2008.

S. Kyamanya, R. Namirembe-Ssonkko and Z. Muwanga. 2009. Field performance of tomato grafted onto indigenous solanaceous rootstocks. Abstract submitted for World Horticulture Conference, to take place in Nairobi, Kenya, in October, 2009.

Klienhenz, M. 2009. Delivered three lectures at MU/FA September 23-25, 2009: (1) Lecture to 2nd year students on season extension and vegetable grafting; (2) Lecture to 3rd year students on season extension and vegetable grafting; (3) Major horticulture, food-society, and professional development issues. (30 M/24 F).

Kuria S.N, J.M. Kibaki, A.M. Ndegwa, M.M. Waiganjo, R.G. Munene. 2009. Evaluation of Tomato Breeding Lines for Resistance/Tolerance to Bacterial Wilt (*Ralstonia solanacearum).* Paper presented at the Egerton fourth Annual Week and International Conference, 16-17 Sept. 2009. In book of Abstract p. 8-9.

Miller, S.A., Z.M. Kinyua, F. Beed, Z.L. Harmon, J. Xin, R.L. Gilbertson and L. Garcia. 2009. The International Plant Diagnostic Network in Africa: Improving capacity for diagnosing diseases of banana and other African crops. Banana 2008: Harnessing International Partnerships to Increase Research Impact. October 5-9, Mombasa, Kenya.

Otipa, M.J. 2009. Presented Passion fruit work a collaboration with Ohio State University under IPM-CRSP Project funded by USIAD, To Her Excellency Secretary of State Hillary Rodham Clinton and Secretary of Agriculture Tom Vilsack, and Congress woman Nita Lowey (New York) and Congressman Donald Payne (New Jersey) and African Advisor To Secretary of State John Carson AT KARI on August 5th 2009, Nairobi, Kenya.

Otipa, M.J. 2009. Passion fruit diseases affecting Passionfruit production and their management in Kenya. Presented at GTZ/Stakeholders workshop of Passion fruit Value Chain at Genevive Hotel in Nakuru, Kenya on 4th to 5th June 2009.

Otipa, M.J, R.L. Amata, M. Waiganjo, J.G. Mureithi, L.E. Ateka, E. Mamati, D. Miano, J. Kinoti, S. Kyamanywa, M. Erbaugh and S. Miller. 2009. Viruses and Dieback diseases threaten Passionfruit Production systems in Kenya. Presented at Africa Crop Science Conference on 28th September to 2nd October 2009 in Cape Town, South Africa.

Otipa, M J, L.A. Wasilwa and R.L. Amata. 2009. Production Trends of Passion fruit in Kenya. Presented at All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya.

Waiganjo, M.M, S. Kyamanywa, M. Maerere, K. Sibuga, R. Amata, S. Kuria, J. Kahinga, M. Otipa, M. Erbaugh, J. Kovach, R. Namirembe-Ssenko, J. Karungi and M. Ssemakula. 2009. An overview of recent achievements and challenges in the USAID-IPM CRSP activities among smallholder tomato and passionfruit growers in East Africa. Presented at All Africa Horticulture Congress, 31st August to 3rd September 2009, Nairobi, Kenya.

Waiganjo M.M, I. Onyango, S.N. Kuria, S.B. Wepukhulu, M.N. Wabule, M. Erbaugh, and J. Kovach. 2008. Environmentally Safe and Cost Effective Tomato Pest Management Options for Small Holder Growers At Thika, Kenya. Presented during the 8th Workshop on Sustainable Horticultural Production in the Tropics held at Masinde Muliro University of Science and Technology (MMUST), KAKAMEGA December 8th-11th 2008.

West Africa

Publications

58 booklets on IPM techniques and 30 on the safe use of pesticides have been distributed.

South Asia

Publications and Presentations

Heinrichs, E.A. 2008. Grafting workshop conducted in India. In: IAPPS Newsletter, April, 2008.

Luther, G. 2008. Grafting Workshops Conducted in India. In: IAPPS Newsletter, Number X, October, 2008.

Nahar, M.S., M.A. Rahman, G.N.M. Ilias, M.A. Rahman, R. Sulatana, A.N.M.R. Karim and S. Miller. 2009. Tricho-compost and its use for soil health management and production of some vegetable crops. Paper presented at the II National Seminar on Earthworm Ecology and Environment and IX National Symposium on Soil Biology and Ecology. Institute of Agriculture, Visva-Bharati, Sriniketan-731236, West Bengal, India, 21-23 November 2009 (Accepted for presentation).

M.S. Nahar, M.A. Rahman, G.N.M. Ilias, M. Arefur Rahman, R. Sulatana, A.N.M.R. Karim and S.A. Miller. 2009. Use of nematode as soil enrichment indicator. Paper presented at the II

National Seminar on Earthworm Ecology and Environment and IX National Symposium on Soil Biology and Ecology. Institute of Agriculture, Visva-Bharati, Sriniketan-731236, West Bengal, India, 21-23 November 2009 (Accepted for presentation).

Press Coverage: 3 +1
Paper presented at the Annual Meeting of Phytopathalogical Society of America, Portland Oregon, USA.

Poster presented at the 5th International Conference on Biopesticides, New Delhi.

Southeast Asia

Pinaria, B.A.N, J. Rimbing, B.H Assa, D.T. Sembel, M. Hammig, G. Carner and M. Shepard 2009. Penggunaan *Metarhizium* sp Isolat local untuk pengendalian hama *Plutella xylostella* dan *Crocidolomia binotalis* pada tanaman kubis. (*Application of local strain Metarhizium anisopliae to control Plutella xylostella and Crocidolomia binotalis on cabbage crops*) Eugenia: 14(4):470-476.

Leaflets:

- VAM –*Vesicular Arbuscular Mycorrhizae*
- DAMPING – *DAMPING-OFF*
- PALTAK - *Anthracnose or Twister*
- BALDRAP – *Basal plate rot or bulb rot*
- TRICHODERMA
- HARABAS -*Armyworm and cutworm*
- JET - *Onion Leafminer*
- HANIP - *Thrips*

Posters:

- Nabibigatan ka na ba? (on VAM)
- Magkakasing-gulang sila, may sakit lang ang iba (on Damping-off)
- Ganito ba ang sibuyas mo? (on Paltak or anthracnose or twister)
- Bulok ba ang inani mo? (on Baldrap = basal plate rot or bulb rot)
- Hindi ito basta-basta (Trichoderma)
- Napansin mo ba ang mga ito sa sibuyas mo? (on Harabas = armyworm and cutworm)
- Napasin mo ba ito sa dahon ng sibuyas mo? (on Jet = onion leafminer)
- Dahon ng sibuyas mo ba’y nagkakaganito? (on Hanip = Thrips)

Flip Charts

In addition to the above extension materials, two flip charts were prepared and reproduced in collaboration with TMSD of PhilRice. These are on VAM production and Use and *Trichoderma* sp. These will be given to technicians and/or facilitators for their use in their FFS.

Networking Activities
Networking was 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.

Rapusas, H.R. was resource person/speaker on IPM in rice and vegetables in a training of trainers in the Palay Check System. PhilRice, Jan. 2009.

Rapusas, H.R. was resource person/speaker on IPM in rice and vegetables in a training of trainers in the Palay Check System. PhilRice, August, 2009.

Rapusas, H.R. was resource person/speaker on IPM on vegetables to the faculty of the National Agricultural University in San Carlos City, Pangasinan

Santiago, S. E. was resource person/speaker on the use and mass production of *Trichoderma* sp. in a training of trainers in the Palay Check System. PhilRice CES and PhilRice Isabela in February 2009.

Santiago, S.E. was resource person/speaker on the use and mass production of *Trichoderma* sp. in a training of trainers in the Palay Check System. PhilRice CES. August, 2009

Ramos, J.M. was resource person/speaker on the use and mass production of VAM in a training of trainers in the Palay Check System. PhilRice CES in February 2009.

Ramos, J.M. was resource person/speaker on the use and mass production of VAM in a training of trainers in the Palay Check System. PhilRice CES. August, 2009.

Presentations in national and international conferences:

Poster Presentation:

Weiler, L.F., A.V.C. Alcala, A.B. Estoy, H.R. Rapusas and X.H. Truong. 2009. Pathogenesis of Entomphthoran Fungi on Silverleaf Whitefly, *Bemisia argentifolii* Bellows & Perring. Poster presented during the PhilRice 23rd Anniversary and R & D Conference. PhilRice CES. March 17-19, 2009.

Publications:

Rapusas, H.R., S.E. Santiago, J.M. Ramos, S.M. Roguel, S.A. Miller, M. Hammig, and B.M. Shepard. 2009. Integrated Pest Management: Assessment of Implementation in Rice-Vegetable Cropping Systems. The Philippine Entomologist. April 2009. In Press.

Opena, J.L., C.B. Adalla, A.M. Baltazar, and N.L. Opina. 2009. Mass rearing and the use of predatory earwigs against eggplant fruit and shoot borer. Leaflet prepared for IPM CRSP trainees. U.P. Los Banos, College, Laguna, Philippines.

Opena, J.L., and A.M. Baltazar. 2009. Integrated weed management using stale-seedbed and other cultural practices in eggplant and pechay in southern Luzon, Philippines. Presented at the 40th conference of the Pest Management Council of thePHilippines. Baguio City, Philippines. May 5-8, 2009

Central Asia

Referred journals

Saidov N.SH. and A.D. Landis. 2008. Evaluation of flowering plants to attract natural enemies in Tajikistan. News of the Academy of sciences of the Republic of Tajikistan, № 4 (165), p. 19-28 *(in Russian).*

Saidov N.SH. and A.D. Landis. 2008. Evaluation of flowering plants to attract natural enemies in Tajikistan. Proceeding of the Conference devoted to 50 years Kazakh Research Institute of Plant Protection and Quarantine, Almata, Kazakhstan, November 2008, vol. I, p.127-132 *(in English).*

Proceedings

Tashpulatova B., F. Zalom and J.T. Tumanov. 2008. Biological control of *Thrips tabaci* (Thysanoptera:Thripidae) using *Amblyseius mckenziei (*Acarina:Phytoseiidae) on onion crop in Kyrgyzstan and Uzbekistan. Proceedings of the International Scientific-Practical Conference "Achievements and problems of plant protection and quarantine" dedicated to the 50th Anniversary of Kazakh Research Institute of Plant Protection and Quarantine. Almaty - Rakhat, Kazakhstan. November 6-8, part 1, pp. 156-158 (in English);

Tashpulatova, B., and F. Zalom. 2008. Studies of the predaceous mites *Amblyseius cucumeris* and *Amblyseius mckenziei* (Acari:Phytoseiidae) in Uzbekistan. International scientific-applied conference "Application of methods of biological control in agriculture". Tashkent, Uzbekistan November 25-26, pp. 38-40 (English)

Pulatov A., B.A.Tashpulatova and M.I. Rashidov. 2008. Study the possibility for introduction and application in Uzbekistan predator mites of Phytoseiidae family, Proceedings of Republic scientific-applied conference of young scientists "Modern technologies of ecologically safe production" Devoted to Youth Year, Tashkent, Uzbeistan pp.54-57. (in Russian)

Tashpulatova B.A. 2009. Mass production and application of *Amblyseius* species predator mites in Uzbekistan. Proceedings of Republic scientific-applied conference of farmers, Tashkent, Uzbekistan April 6-7, 2009. (in Russian)

Saidov N.Sh., D.A. Landis, A. Fiedler, V.K. Nazirov and A. Khalimov. 2008. The role of nectar plants on attraction natural enemies in agrolandscapes. Proceedings of the International Scientific-Practical Conference dedicated to the 60th Anniversary of Department of Biology of National University of Tajikistan. Dushanbe (Душанбе), December 19-20, 2008, p. 27-28 *(in Russian).*

Saidov A.S., N.Sh. Saidov and B.R. Nakhshiniev. 2008. Effect of some aspects of climate change on fauna of Tajikistan. Ninth International Conference on Dryland Development, Sustainable Development in the Drylands Meeting the Challenge of Global Climate Change, 7-10 November 2008, Alexandria, Egypt. Abstracts of oral presentations, p. 38-39 *(in English).*

Saidov N.Sh. and D.A. Landis. 2008. Landscape ecology and biodiversity to enhance biodiversity and biological pest management. Ninth International Conference on Dryland Development, Sustainable Development in the Drylands Meeting the Challenge of Global Climate Change, 7-10 November 2008, Alexandria, Egypt. Abstracts of oral presentations, p. 82-83 *(in English).*

Aitmatov M.B., G. Bird, A.U. Jalilov and K. Kyjal. 2008. Farm Field School and ecology problem. Beatnik Kyrgyz agrarian university. № 3 (11), 2008. 10-14 pg. (in Russian).

Hamraev A.S., N.S. Saidov, M.B. Aitmatov, S.A. Azimov, S.B. Ulmesbaev and B.A. Tashpulatova Books: Agroentomological cartogram for Central Asia and Caucasus regions.

ICARDA-Michigan and Uzbek zoology institute of academy of sciences, Tashkent. 2008. 123 p, (in Russian), published copies 500 units.

Kubat, J., M. Rashidov and M. Aitmatov. 2008. Terminological dictionary on plant protection. (in Russian, Kirghiz, Latin, Uzbek and English) Kyrgyz agrarian university (Kyrgyzstan) and Tashkent State agrarian university (Uzbekistan), Bishkek, 2008. 56 pg.

Bulletins

Saidov N.S.H., A.U. Jalilov and V.K. Nazirov. 2009. Russian-Tajik-English terminological dictionary on plant protection. Dushanbe 60 p., *(in Russian).*

Khamraev A.Sh., N.SH. Saidov, M.B. Aitmatov, D.A. Azimov, Sh.B. Ulmasbaev and B.A. Tashpulatova. 2008. Agroetomological cartogram for Central Asia and Caucasus countries. Scientific-practical recommendation, Tashkent, 125 p. *(in Russian).*

Aitmatov M.B., G. Bird, A.U. Jalilov and K. Kyjal. 2008. Farm Field School and ecology problem. Beatnik Kyrgyz agrarian university. № 3 (11): 10-14 pj. (in Russian)

Extension publications

Hamraev A.S., N.S. Saidov, M.B. Aitmatov, S.A. Azimov, S.B. Ulmesbaev and B.A. Tashpulatova. 2008. Agroentomological cartogram for Central Asia and Caucasus regions.

ICARDA-Michigan and Uzbek zoology institute of academy of sciences. 2008. Tashkent, 123 p, in Russian.

Junusuv K., M. Rashidov and M. Aitmatov. 2008. Terminological dictionary on plant protection. (in Russian, Kirghiz, Latin, Uzbek and English) Kyrgyz agrarian university (Kyrgyzstan) and Tashkent State agrarian university (Uzbekistan), Bishkek, 56 pg.

Saidov N., D. Landis, A. Fiedler**,** M. Bouhssini, V. Nazirov and A. Jalilov. 2009. Introduction of native flowering plants in agro landscapes for attracting beneficial insects. Extension Bulletin, Dushanbe, 12 p., *(in Russian).*

Saidov N., D. Landis, A. Fiedler**,** M. Bouhssini, V. Nazirov and A. Jalilov. 2009. "Introduction of native flowering plants in agro-landscapes for attracting beneficial insects." Dushanbe, 12 p. *in Russian language.*

Manuals

Tashpulatova B.A., F. Zalom, M.I. Rashidov and B. Suleimanov. 2009, Methodological recommendation on rearing of predator mites (Phytoseiidae family) for biological control of greenhouse pests, Handbook. Tashkent-2009, Tashkent, 18 p, published copies 100 units (in Russian)

Other

In January 2009, through the support of Ms. Joy Landis, IPM communications manager at MSU, the Project established a new web site featuring its work and collaborators. The address of the web site is: http://ipm.msu.edu/central-asia.htm. The site features a description of each project component, reports and publications, photos and blog entries along with an IPM directory of IPM specialists and stakeholders in Central Asia.

Joy Landis also established a blog documenting the team's travel and meetings in Central Asia during spring 2009: http://www.ipmglobal.blogspot.com/. The blog is intended to help the general public understand how American science (specifically in IPM) can be leveraged to help raise the standard of living and improve the environment in countries like those in Central Asia. The blog features collaborations between the people of the region and the U.S. based project team. The blog has received over 425 visits from 293 visitors with more than 700 page views since June 1, 2009. The blog will be continued during the next phase of the Central Asia project and will be positioned to send traffic to the web site.

Presentations

Saidov, N. and D. Landis. 2009. Enhancing pest management in organic farming via conservation biological control. 2^{nd} International Conference on Organic Sector Development in Central/Eastern European and Central Asian countries, Tbilisi, Georgia.

Tashpulatova, B. and F. Zalom. 2009. Enhancing the Efficiency and Product Lines of Biolaboratories in Central Asia. Central Asia Stakeholders Forum, Bishkek, Kyrgyzstan.

Saidov, N., D. Landis, A. Fiedler, V.K. Nazirov and A. Khalimov. 2008. The Role of Nectar Plants on Attraction Natural Enemies in Agro-Landscapes. The 60th Anniversary of the Department of Biology of the National University of Tajikistan, Dushanbe, Tajikistan.

Tashpulatova, B. and F. Zalom. 2008. Biological control of *Thrips tabaci* (Thysanoptera: Thripidae) using *Ambliseius mckenziei* (Acarina: Phytoseiidae) on onion crop in Kyrgyzstan and

Uzbekistan. Conference for the 50th anniversary of Kaz. Scientific Res. Institute of Plant Protection and Quarantine, Almaty, Kazakhstan.

Tashpulatova, B. 2008. “Application of methods of biological control in agriculture,” Tashkent, Uzbekistan.

Saidov, N. and D. Landis. 2008. Landscape ecology and biodiversity to enhance biodiversity and biological pest management. 9th International Conference on Dryland Development, Sustainable Development in the Drylands Meeting the Challenge of Global Climate Change, Alexandria, Egypt.

Maredia, K., F. Zalom and D. Baributsa attended the Sixth International IPM Symposium in Portland, Oregon from March 22 - 25, 2009. Two posters were presented covering research results and outcomes of the Central Asia IPM CRSP project.

Eastern Europe

Publications

Pace, H. and J Tedeschini. 2009. 1-Effects of soil solarization for controlling soil-borne fungi in tomato plastic houses in Albania. (Buletini i Shkencave Bujqesore Nr1 2009).

Posters

Implementation of IPM Scouting Program for Tomato and Cucumber Crop Production in Albanian Greenhouses (J. Tedeschini, H. Paçe, E. Çota, S. Gjini and D. Pfeiffer)

An Alternative Approach to Increasing Tomato Production by Reducing Incidences of Corky Root by Grafting in Albania (J. Tedeschini, H. Paçe, B. Alushi and D. Pfeiffer)

Integrating Fungicidal Control Programs to Maximize Economic Return on Tomato Production in Albanian Greenhouses. (J. Tedeschini, H. Paçe, I. Papingji and D. Pfeiffer).

Investigations on Population Dynamics and Bio-control Effectiveness for *Aphis gossypii* in Greenhouse Vegetables (Sh. Shahini, E. Kullaj, J. Tedeschini and D. Pfeiffer).

IOBC/WPRS Working Group- Integrated Control in Protected Crops, Mediterranean Climate Chania Crete, (Greece) 6-12 Sept, 2009.

Integrating Fungicidal Control Programs to Maximize Economic Return on Tomato Production in Albanian Greenhouses. (J. Tedeschini, H. Paçe, I. Papingji and D. Pfeiffer), p 41-44, IOBC wprs Bulletin Vol 49, 2009.

Reduction of the corky rot infection by soil solarization in greenhouse tomato production in Albania (H. Paçe, J. Tedeschini and D. Pfeiffer), p67-70, IOBC wprs Bulletin Vol 49, 2009.

Eco-friendly management of root-knot nematode *Meloidogyne incognita* in Albania. (V. Jovani, J. Tedeschini, A. Ramadhi and D. Pfeiffer), p71-76, IOBC wprs Bulletin Vol 49, 2009.

4th Annual Meeting of Alb-Shkenca Institute, Tetova 31 August- 2 September 2009, Macedonia

Evaluation of impact of pesticides on *Botrytis cinerea* under different disease control programs in Albanian greenhouses (J. Tedeschini, H. Paçe and D. Pfeiffer).

Integrated control of root knot nematode by using bionematacides and biostimulants in some protected vegetable crops in Albania (A. Ramadhi and V. Jovani).

Presentations

International Conferences "Integrated systems of field crops pest management, Balti 2009 and IOBC WORKING GROUP "Integrated Control in Protected Crops, Mediterranean Climate" 6-11 September 2009 Chania (Insecto-acaricidal effect of microemulsion based on rape seed oil derivatives V. Todirash , D.G. Pfeiffer, T. Tretiacov and V. Focsa)

The book Integrated pest management and quality assurance of stored products, 2009 (in Romanian) authors V. Todiras, Iu Balan.,T. Tretiacov, was edited and published.

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

Publications

Graduate Student Research:

Edessa, S. 2009. Effectiveness and Biology Studies of *Zygogramma Bicolorata P.* (Coleoptera: Chrysomelidae) on *Parthenium Hysterophorus* L. and Safety Tests on Some Related Plant Species from Astreacae Family under Quarantine Conditions, Ambo University, MS Thesis.

Publications (Book chapters and Journals)

Dhileepan, K. and L. Strathie. 2009. *Parthenium hysterophorus* L. (Asteraceae). In: *Biological Control of Tropical Weeds using Arthropods*, ed. R. Muniappan, G.V.P Reddy, and A. Raman. Cambridge University Press, pp. 274-318.

Nigatu L, A. Hassen, and J.J. Sharman. 2008. The impact of parthenium on herbaceous vegetation and soil seed bank flora in sorghum fields in North Eastern Ethiopia" Ethiopian Journal of Weed Management, 2:

McConnachie, A.J., L.W. Strathie, W. Mersie, L. Gebrehiwot, K. Zewdie, A. Abdurehim, B. Abrha, T. Araya, F. Asaregew, S. Assefa, R. Gebre-Tsadik, L. Nigatu, B. Tadesse and T. Tana. 2009. Current and potential geographical distribution of the invasive plant *Parthenium hysterophorus* (Asteraceae) in eastern and southern Africa. *Submitted to Biological Invasions.*

Hailu B, L.Gebrehiwot, S. Regassa, M. Dejene, B. Tadesse, T. Tana, L. Nigatu, A. Dejen and W. Mersie. 2008 The Impact of the Invasive Weed Parthenium (*Parthenium hysterophorous* L.) on the Lives of Farmers and Agro-pastoralists in Ethiopia. Submitted to East African Journal of Sciences (EAJS).

Lisanework N, A. Hassen, J.J. Sharma and S. Adkins. 2009. Impact of *Parthenium hysterophorus* L. on grazing land communities in North-Eastern Ethiopia.

Submitted to Weed Biology and Management.

Other Publications

Parthenium Weed Identification Kit leaflet. Two pages. A. Shabbir and S. Adkins

Success story of Shashie Ayele, IPM CRSP Sponsored Graduate Student in Ethiopia.

Pioneer weed biocontrol quarantine facility for Ethiopia in the battle to control the invasive plant parthenium in Africa

Planning Meeting

The 4th Parthenium Partners Reporting and Planning Workshop was held on 13-16 October, 2008 at Imperial Hotel, in Addis Ababa, Ethiopia. Attendance was forty on the first day and thirty on the second day. There were only three female participants.

Two national newspapers, the daily Addis Zemen in Amharic, and the Ethiopian Herald in English reported about the parthenium workshop in their October 14 and 15 issues, respectively. Both newspapers circulate throughout the country.

Presenatations in workshops and/or meetings

Adkins, S.W. 2008 Parthenium Weed Research Aids Management of this Weed in the Agro ecosystems of Ethiopia and Pakistan. The 5th International Weed Science Congress, 23-27 June 2008, Vancouver, Canada. Approximately 550 delegates of which about 50% female.

Adkins, S.W. 2008. Parthenium Weed; An Invasive Weed of the Agro ecosystems of Australia, Ethiopia and Pakistan. Seminar at Kew Gardens, Wakehurst Place, England. Approximately 35 in audience of which c. 50% female.

Bisikwa, J. 2008. The Status of Invasive Plant Management in Uganda at The 4th Partners Planning and Reporting Regional Workshop, Addis Ababa, October 13-15, 2008.

Bisikwa, J. 2009. Status of Invasive alien species in Ugandan Ecosystems featuring The Case of Parthenium Weeds Problem in Uganda at The EATRINET/UVIMA Awareness Workshop, Kampala, Uganda, February 26th, 2009.

Bisikwa, J. 2009. Parthenium Weed Problem Spreads to Uganda at The 5th Technical Committee Meeting and Progress Report Workshop of Integrated Pest Management March 1st-4th, 2009, Kampala, Uganda.

Abebe M. and N. Mulugeta. 2008. Screening for Safety and Mass Production of Bio-Control Agent (*Zygogramma bicolorata),* Under Quarantine Conditions at PPRC, EIAR, Ambo, Ethiopia. The 9th Annual Conference of the Ethiopian Weed Science Society held on 25-26 December 2008 in Hiruy Hall, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.

Kemal Ali, Mulugeta Negeri, and Takele Negewo participated in Invasive Weed Management Workshop and Field Day that was organized by Wonji sugarcane enterprise and UNEP/GEF project on "Removing Barriers to Invasive Plant Management" from 27-29, 2009.

Taylor, J., K.P. Kirkman, A. McConnachie and L. Strathie. 2009. Seed Bank Studies of the Alien Invasive Weed, *Parthenium hysterophorus* L., in the Eastern Areas of South Africa. South African Crop Production/Soil Science Society of South Africa/South African Society for Horticultural Sciences/South African Weed Science Society Combined Congress 2009, Stellenbosch University, Stellenbosch, 19-22 January 2009.

McConnachie, A. 2008. Parthenium Distribution Studies – the Relevance for Biocontrol Mass-rearing. IPM CRSP Parthenium Project Partners Workshop 13-16 October 2008, Addis Ababa, Ethiopia. (30 participants including 3 females)

McConnachie, A. 2008. Biological control of invasive plant species. IPM CRSP Parthenium Project Partners Workshop 13-16 October 2008, Addis Ababa, Ethiopia. (¬ 30 participants including 3 females)

Strathie, L. 2008. Biological Control Programmes and Determining Safety of Agents. IPM CRSP Parthenium Project Partners Workshop 13-16 October 2008, Addis Ababa, Ethiopia. (30 participants including 3 females)

Strathie, L. 2008. Rearing and Testing Agents for Biological Control of *Parthenium hysterophorus* in South Africa. IPM CRSP Parthenium Project Partners Workshop 13-16 October 2008, Addis Ababa, Ethiopia. (Including 3 females participants)

Strathie, L. 2009. Promising Prospects for Biological Control of *Parthenium hysterophorus*. 37th Annual Biocontrol of Weeds Workshop, Green Fountain Farm, Port Alfred 5-8 May 2009. (80 biocontrol researchers, implementers, managers, approx. 50% female)

Strathie, L. and C. Zachariades. 2009. Biological Control of Alien Invasive Plants. Ivungu River Conservancy, 19 May 2009, Port Edward. (30 members of public, approx. 50% female)

Taylor, J., K.P. Kirkman, A. McConnachie and L. Strathie. 2009. Seed Bank Studies of the Alien Invasive Weed, *Parthenium hysterophorus* L., in the Eastern areas of South Africa. South African Crop Production/Soil Science Society of South Africa/South African Society for Horticultural Sciences/South African Weed Science Society Combined Congress 2009, Stellenbosch University, Stellenbosch, 19-22 January 2009.

Thrips-borne Tospoviruses

Chitturi, A. 2010. Thrips in Vegetables in India Associated with Tospovirus: *Thrips tabaci* Transmission of IYSV and Behavioral Studies in Onion. University of Georgia PhD Dissertation in preparation fall semester 2009.

Chitturi, A., S. Diffie and D.G. Riley. 2010. First report of *Thrips hawaiiensis* (Thysanoptera: Thripidae) in Vegetables in India. Journal of Economic Entomology – Scientific Note in preparation fall semester 2009.

Chitturi, A. and D.G. Riley. 2010. Survey of Thrips in Vegetables in India Associated with Tospovirus. Environmental Entomology in preparation fall semester 2009.

Chitturi, A., D.G. Riley and R. Srinivasan. 2010. Onion seedling bioassay for onion thrips transmission of *Iris yellow spot virus*. Plant Disease in preparation fall semester 2009.

Chitturi, A. and D.G. Riley. 2010. Within Plant distribution of *Thrips tabaci* (Thysanoptera: Thripidae) settling, oviposition and IYSV incidence in onion. Environmental Entomology in preparation fall semester 2009.

Chitturi, A. and D.G. Riley. 2010. Inter specific thrips (Thysanoptera: Thripidae) competition for reproduction and virus transmission on onion. Crop Protection in preparation fall semester 2009.

Damayanti, T.A. and R.A. Naidu. 2009. Identification of *Peanut bud necrosis virus* and *Tomato spotted wilt virus* in Indonesia for the first time. Plant Pathology 58: 782.

Damayanti, T.A., O.J. Alabi, R.A. Naidu and A. Rauf. 2009. Severe outbreak of a viral disease in yard long bean (*Vigna unguiculata* subsp. *Sesquipedalis*) in Indonesia. HAYATI Journal Biosciences (accepted).

Damayanti, T.A., O.J. Alabi, A. Rauf, and R.A. Naidu. 2009. The occurrence of *Bean common mosaic virus* and *Cucumber mosaic virus* in yardlong beans in Indonesia. Plant Disease (submitted).

Riley, D., R. McPherson and L. Wells. 2009. Thrips vectors of TSWV, pp 13-16. *In* "Tospoviruses in Solanaceae and Other Crops in the Coastal Plain of Georgia". University of Georgia CAES Research Report Number 704 revised and in press September 2009.

Riley, D., R. McPherson, L. Wells and S. Brown. 2005. Management of thrips vectors of TSWV, pp 24-26. *In* "Tospoviruses in Solanaceae and Other Crops in the Coastal Plain of Georgia". University of Georgia CAES Research Report Number 704 revised and in press September 2009.

Abstracts

Kumar, P.L., O.J. Alabi, R. Hanna and R.A. Naidu. 2009. Coat protein-based genealogy of *Banana bunchy top virus* in the sub-Saharan Africa. Phytopathology 99: S68.

Sudarsana, P., T. Damayanti, M. Karuppannan, O.J. Alabi, G. Karthikeyan, P.L. Kumar, A. Rauf, G. Kodetham and R.A. Naidu. 2009. Diagnosis of plant viruses using FTA Classic Card technology. Phytopathology 99:S125.

Conference presentations

Adkins, S., G. Karthikeyan, T. Damayanthi, G. Kodetham, D.J. Riley and R.A. Naidu. 2009. IPM CRSP project on tospoviruses and thrips vectors in South and Southeast Asia. IX International Symposium on Thysanoptera and Tospoviruses, 31 August – 4 September 2009, Queensland, Australia

Sudarsana, P., T. Damayanti, M. Karuppannan, O.J. Alabi, G. Karthikeyan, P.L. Kumar, A. Rauf, G. Kodetham and R.A. Naidu. 2009. Diagnosis of plant viruses using FTA Classic Card technology. American Phytopathological Society Annual Meeting, August 1-5, 2009. Portland, OR.

Kumar, P.L., O.J. Alabi, R. Hanna and R.A. Naidu. 2009. Coat protein-based genealogy of *Banana bunchy top virus* in the sub-Saharan Africa. American Phytopathological Society Annual Meeting, August 1-5, 2009. Portland, OR

Balakrishnan, N., R.A. Naidu, G. Karthikeyan, T.A. Damayanthi, G. Kodetham, D.J. Riley and S. Adkins. 2009. An IPM approach for the management of thrips-transmitted tospoviruses in vegetable cropping systems in South and Southeast Asia. Washington State University Academic Showcase, March 27, 2009, Pullman, WA.

Naidu, R.A., G. Karthikeyan, T.A. Damayanthi, G. Kodetham, D.J. Riley and S. Adkins. 2009. An IPM Approach for the Management of Thrips-transmitted Tospoviruses in Vegetable Cropping Systems in South and Southeast Asia. 6th International IPM Symposium-Transcending Boundaries, March 24-26, 2009, Portland, Oregon.

Riley, D. and A. Chitturi. 2008. Thrips in vegetables in India associated with Tospovirsuses and specifically IYSV transmission in onion. South Eastern Branch Entomological Society of America. Wyndham Jacksonville Riverwalk Hotel, FL. March 4, 2008.

Chitturi, A. and D.G. Riley. 2008. Characterizing the settling behavior of *T. tabaci* (Thysanoptera: Thripidae) on onion foliage. Annual Meeting of the Entomological Society of America. Reno, NV, November 16-19, 2008.

Chitturi, A. and D.G. Riley. 2008. Survey and behavior studies of *Thrips tabaci (Thysanoptera: Thripidae)* on onion in India and Georgia, USA. 1st Place Graduate Student Poster Award at the National Allium Research Conference, Savannah, Georgia, December 10-13, 2008.

Lecture presentations

Kodetham Gopinath. 2009. "Screening of yeast proteome and the Role of cellular proteins on Brome mosaic virus RNA replication, systemic movement and long distance RNA trafficking."

International seminar on Plant Biotechnology and Genomics towards a New Green Revolution (ISPBG2009), February 6-7, 2009.

Naidu Rayapati. 2009. "Thrips-borne tospoviruses and their management and how the IPM CRSP funded project is generating knowledge that could be used to develop IPM tactics for the management of PBNV." Department of Plant Pathology, Center for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore, India, August 19, 2009.

Naidu Rayapati 2009. "Dealing complex virus disease problems – a case of tospovirus disease in vegetables." Department of Department of Plant Molecular Biology & Biotechnology, Center for Plant Molecular Biology, Tamil Nadu Agricultural University, Coimbatore, India, August 20, 2009.

Kodetham Gopinath. 2009. "Reconstitution of Brome Mosaic virus infection through RNA trafficking and the role of two yeast cellular proteins on RNA transport." Trends in Plant Biology Mini Symposium, Indian Institute of Education and Research Institute, Pune, India, August 8, 2009.

Karthikeyan Gandhi. 2009. "Detection of seed borne viruses." National Training Course for Seed Testing Officers, National Seed Research & Training Institute, Varanasi, U.P., India, July 13-17, 2009.

Naidu Rayapati. 2009. "International Partnerships: Why it Matters for Africa?" International Institute of Tropical Agriculture, Lagos, Nigeria, May 8, 2009.

Insect Transmitted Viruses in Central America, the Caribbean and Sub-Saharan Africa.

Brown, J.K., D. Rogan, A.M. Idris, R.R. Martin and M. Rehman. 2009. First report of a Ca. Liberibacter-like bacaterium associated with tomato vein-greening disease in commercial greenhouses in Arizona. Plant Dis. (accepted).

Batuman, O., Y.W. Kuo, M. Palmieri, M.R. Rojas and R.L. Gilbertson. Tomato chocolate spot disease in Guatemala is caused by a new plant picorna-like virus from tomato related to tomato torrado, marchitez and apex necrosis viruses. Archives of Virology. (accepted for publication pending suitable revision).

Chang, P.S. 2009. Plant virus diagnostics: Comparison of classical and membrane-based techniques for immunoassay and coat protein sequence characterization for *Cucumber mosaic virus* and three potyviruses. Ph. D. Dissertation, Virginia Polytechnic Institute and State University. 106 p.

Chen, L.-F., M.R. Rojas, T. Kon, K. Gamby, B. Xoconostle-Cazares and R.L. Gilbertson. 2009. A severe symptom phenotype in tomato in Mali is caused by a reassortant between a novel recombinant begomovirus (Tomato yellow leaf curl Mali virus) and a betasatellite. Mol. Plant Pathol. 10: 415-430.

Chang, P.S. and S. Tolin. 2009. Nitrocellulose membranes as a solid matrix for *Cucumber mosaic virus* immuno-detection and subgroup identification by RT-PCR. Phytopathology 99: (in press).(Abstract).

Kon, T., M.R. Rojas, I.K. Abdourhamane, and R.L. Gilbertson. 2009. The roles and interactions of begomoviruses and satellited DNAs associated with okra leaf curl disease in Mali, West Africa. J. Gen. Virol. 90: 1001-1013.

Leke, W.N., D.K. Njualem, V.P. Nchinda, Z. Ngoko, S. Zok, J.M. Ngeve, J.K. Brown and A. Kvarnheden. 2009. Molecular identification of *Maize streak virus* reveals the first evidence for a subtype A1 isolate infecting maize in Cameroon. Plant Pathology 58: 782. New Disease Reports [http://bspp.org.uk/ndr/] Vol. 19.

Leke, W.N. et al., 2006. Detection and identification of begomoviruses from landraces of okra (*Abelmoschus esculentus*) in Cameroon. Cam. J. Agric. Sci. 2(1) (in press).

Leke, W.N., Brown, J.K., Sattar, M.N., Ngane, E.B. and Kvarnheden, A. 2010. A complex of begomoviruses including a new recombinant species, a promiscuous DNA beta- satellite, and one typical and one novel DNA beta- satellite from symptomatic okra plants in Southwestern Cameroon. Virus Res. (submitted).

Leke, W.N., Kvarnheden, A., and Brown, J.K. 2010. Diversity and novel DNA satellites associated with monopartite begomoviruses in the equatorial rain forest region of Cameroon. Journal of General Virology (submitted).

Leke, W.N., Brown, J.K., Ngane, E.B., Tatanji, V.P.K., and Kvarnheden, A. 2010. A new begomovirus and an associated alphasatellite infecting tomato in Cameroon. Arch. Virol (submitted).

Salati, R., M. Shorey, A. Briggs, J.Calderon, M.R. Rojas, T. Kon and R.L. Gilbertson. 2009. First report of Tomato yellow leaf curl virus infecting tomato, tomatillo and peppers in Guatemala. Plant Dis. (accepted for publication pending suitable revision).

Publications in preparation/under review

Brown, J.K., M. Rehman, J.C. Melgar and J.M. Rivera. 2009. First report of an uncultured *Candidatus* Liberibacter species from potato crops and potato psyllids in Honduras. Plant Dis. (submitted)

Leke, W., M.N. Sattar, E.B. Ngane, J.M. Ngeve, J.K. Brown and K. Anders. 20xx. A complex of begomoviruses including a new recombinant species, a promiscuous DNA-β satellite, and one typical and one novel DNA-α satellite from symptomatic okra plants in Southwestern Cameroon. Virus Research (submitted)

Brown, JK, N. Merchant, and J. Legg. Composition of hybrid and non=hybrid *B. tabaci* in the severe cassava mosaic virus pandemic zone in east and central Africa using two molecular markers. (in preparation).

Brown, JK, M Kaplan, H-W Hermann, N. Merchant, and J. Legg. Microsatellite isolation, validation, and application to dissect the population genetics of *B. tabaci* associated with the severe cassava mosaic pandemic in eastern and central Africa (in preparation).

Koutou, M, JK Brown, and A Kvarnheden. Molecular characterization of begomoviruses infecting tomato and pepper in Burkina Faso and evidence of occurrence of mixed infection. (in preparation)

Koutou, M, JK Brown, and A. Kvarnheden Evidence of mixed infection of *African cassava mosaic virus* (ACMV) and *East African cassava mosaic virus* (EACMV) in cassava from Burkina Faso. (in preparation).

Chang, P.-G. and S. Tolin. Immunoassay, RT-PCR and direct sequencing of *Cucumber mosaic virus* and potyvirus coat proteins from the same NitroPure nitrocellulose membrane.

Presentations

Leke, W.N., E.B. Ngane, D.K. Njualem, V.P.K. Titanji, J.P. Legg, J.M. Ngeve, S. Zok, J.K. Brown and A. Kvarnheden 2009. Provisional identification of begomoviruses associated with cultivated and endemic plant species from Southwestern Cameroon based on core coat protein sequence analysis. Advances in Plant Virology conference 1-3 April 2009, Harrogate, York, UK

Leke, W.N., D.K. Njualem, V.P.K. Titanji, J.P. Legg, J.M. Ngeve, J.K. Brown, and A. Kvarnheden. 2009. Diversity of DNA satellite molecules associated with monopartite begomoviruses in the equatorial rain forest region of Cameroon. 9 ACSS conference, Cape Town, South Africa. Sept 27- Oct 1, 2009.

Chang, P.-G. and S. Tolin. 2009. Nitrocellulose membranes as a solid matrix for *Cucumber mosaic virus* immuno-detection and subgroup identification by RT-PCR. Presentation at the annual meeting of the Caribbean Division of the American Phytopathological Society, Orlando, FL. Received first place award in graduate student completion at this meeting.

Tolin, S. and Chang, P.-G. 2009. Contributions of the IPM-CRSP to virus diagnosis and management in Central America and the Caribbean. Presentation at the annual meeting of the Caribbean Division of the American Phytopathological Society, Orlando, FL. May 16-19, 2008.

Gilbertson, R. G. 2009. IPM for insect-transmitted viruses: whitefly-transmitted begomoviruses infecting tomatoes n West Africa. Presentation at the Sixth International IPM Symposium “Transcending Boundaries”, at the session entitled: IPM strategies for the management of insect-transmitted plant virus diseases. March 24-26, 2009. Portland, OR.

Palmieri, M., A. Avalos, L. Ortiz, M. Valazquez, E. Solares, M. Morales, A. Font, J. Brown, and R. Gilbertson. 2009. Management of whitefly transmitted virus diseases in a developing country – a case study. Presentation at the Sixth International IPM Symposium “Transcending Boundaries”, at the session entitled: IPM strategies for the management of insect-transmitted plant virus diseases. March 24-26, 2009. Portland, OR.

Tolin, S. A. 2009. Success Stories: Contributions of USAID and IPM-CRSP to the management of virus diseases in developing countries. Presentation at the Sixth International IPM Symposium "Transcending Boundaries", at the session entitled: IPM strategies for the management of insect-transmitted plant virus diseases. March 24-26, 2009. Portland, OR.

Presentation on "Basics of Integrated Management of Virus and Virus-like Diseases of Vegetable Crops". On September 22 in La Lima and on September 28 in Comayagua J. C. Melgar lectured groups of 20 and 32 extension workers of the MCA- and USAID-funded EDA and RED projects, respectively. The focus of the 3 hr-long talks was the general biology of viruses and their means of transmission as determinants of the strategies used for their integrated management. In addition, the findings on "Zebra chip" disease of potatoes were also presented in these occasions.

Petit, G., J.M. Rivera, J. C. Melgar, S. Tolin and J. Brown. 2008. Reaction to virus diseases and effect of plastic mulch on virus incidence and severity of commercial tomato cultivars in the field. Presentation at a work session of the XI International Congress on IPM of the Mesoamerican region, held in Tegucigalpa, Honduras October 8-10, 2008.

Posters

Noussourou, M., K.T. Gamby, A.D. Nantoume, A.I. Kollo, R. Gilbertson, R. Foster, A. Diarra, and L. Vaughan. 2009. Integrated control strategies for tomato viruses in Mali, West Africa. Sixth International IPM Symposium "Transcending Boundaries", March 24-26, 2009. Portland, OR.

IPDN

Publications

Miller, S. A., F. Beed and C.L. Harmon. 2009. Plant disease diagnostic capabilities and networks. *Annual Review of Phytopathology* 47:15-38.

Miller, S.A., Z.M. Kinyua, F. Beed, C.L. Harmon, J. Xin, P. Vergot, T. Momol, R. Gilbertson and L. Garcia. 2009. The International Plant Diagnostic Network (IPDN) in Africa: Improving capacity for diagnosing diseases of banana and other African crops. *Acta Hort.* (in press).

Lewis Ivey, M.L., G. Tusiime and S.A. Miller. 2009. A PCR assay for the detection of *Xanthomonas campestris* pv. *musacearum* in bananas. *Plant Dis*ease 93 (in press).

Sikirou, R., F. Beed, V. Ezin, G. Gbèhounou, S.A. Miller and K. Wydra. 2009. First report of bacterial wilt of tomato (*Solanum lycopersicum*) caused by *Ralstonia solanacearum* in Benin. *Plant Dis*. 93:549.

Carter, B.A., R. Reeder, S.R. Mgenzi, Z.M. Kinyua, J.N. Mbaka, K. Doyle, M. Maina, G. Valentine, V. Aritua, M.L. Lewis Ivey, S.A. Miller and J.J. Smith. 2009. First report of *Xanthomonas campestris* pv. *musacearum*, causative organism of banana xanthomonas wilt, in

Tanzania, Burundi and Kenya. *New Disease Reports* 19
http://www.bspp.org.uk/publications/new-disease-reports/ndr.php?id=019025.

Zhou, Y.C., M. Noussourou, T. Kon, M.R. Rojas, H. Jiang, L.F. Chen, K. Gamby, R. Foster, and R.L. Gilbertson. 2008. Evidence for local evolution of tomato-infecting begomovirus species in West Africa: characterization of tomato leaf curl Mali virus and tomato yellow leaf crumple virus from Mali. Arch. Virol. 153:693-706.

Kon, T., M.R. Rojas, I.K. Abdourhamane, and R.L. Gilbertson. 2009. The roles and interactions of begomoviruses and satellite DNAs associated with okra leaf curl disease in Mali, West Africa. J. Gen. Virol. 90: 1001-1013.

Chen, L.-F., M.R. Rojas, T. Kon, K. Gamby, B. Xoconostle-Cazares and R.L. Gilbertson. 2009. A severe symptom phenotype in tomato in Mali is caused by a reassortant between a novel recombinant begomovirus (Tomato yellow leaf curl Mali virus) and a betasatellite. Mol. Plant Pathol. 10: 415-430.

Oral Presentations and Posters

Miller, S.A. 2009. Accomplishments of the IPM CRSP Global Theme: Regional Diagnostic Networks. IPM CRSP Technical Committee Meeting, March 23, Portland, OR.

Miller, S.A., Z.M. Kinyua, F. Beed, Z.L. Harmon, J. Xin, R.L. Gilbertson and L. Garcia. 2009. The International Plant Diagnostic Network in Africa: Improving capacity for diagnosing diseases of banana and other African crops. Banana 2008: Harnessing International Partnerships to Increase Research Impact. October 5-9, Mombasa, Kenya.

Harmon, C.L., P. Vergot, J. Xin, T. Momol and S.A. Miller. 2009. Internationalizing plant protection through extension: the International Plant Diagnostic Network. Presented at the 25th Annual AIAEE Conference, San Juan, Puerto Rico, May 24-28. Journal of International Agricultural and Extension Education 16 (2): 72.

Miller, S.A. 2009. The International Plant Diagnostic Network (IPDN): improving capacity for diagnosing diseases and pests of African crops. Department of Crop Protection, Ahmadou Bello University, Zaria, Nigeria.

Agudelo, P. and M. Arevalo. 2009. Plant parasitic nematode identification workshop. Poster prepared for the American Phytopathological Society Office of International Programs, APS Annual Meeting, Portland, OR.

IPM Impact Assessment for the IPM CRSP

Adiyoga, W. and G.W. Norton. 2009. Cost and benefits of *Bt* potato with resistance to potato tuber moth in Indonesia. *In* Norton, G.W. and D.M. Hautea (eds.). Projected Impacts of

Agricultural Biotechnologies for Fruits and Vegetables in the Philippines and Indonesia. SEAMEO, Philippines, 184 p.

Bayer, H.C., G.W. Norton and J.Falck-Zepeda.2009. Level and implications of regulatory costs in commercializing *Bt* eggplant, virus resistant tomato and Bt rice in the Philippines. *In* Norton, G.W. and D.M. Hautea (eds.). Projected Impacts of Agricultural Biotechnologies for Fruits and Vegetables in the Philippines and Indonesia. SEAMEO, Philippines, pp. 163-181.

Norton, G.W. and D.M. Hautea. 2009. Projected Impacts of Agricultural Biotechnologies for Fruits and Vegetables in the Philippines and Indonesia. SEAMEO, Philippines, 184 p.

Norton, G.W. 2009. Methodology, *In* Norton, G.W. and D.M. Hautea (eds.). Projected Impacts of Agricultural Biotechnologies for Fruits and Vegetables in the Philippines and Indonesia. SEAMEO, Philippines, pp 11-22.

Norton, G.W. and D.M. Hautea. 2009. Summary and conclusions. *In* Norton, G.W. and D.M. Hautea (eds.). Projected Impacts of Agricultural Biotechnologies for Fruits and Vegetables in the Philippines and Indonesia. SEAMEO, Philippines, pp. 182-184.

Norton G.W. and Raitzer, D.A. 2009. Synthesis and options for enhanced priority assessment for agricultural and natural resources research. *In* Raitzer, D.A. and G.W. Norton. (eds.) Prioritizing Agricultural Research for Development. CAB International, Oxfordshire, UK, pp. 208-225.

Raitzer, D.A. and G.W. Norton. 2009. Prioritizing Agricultural Research for Development. CAB International, Oxfordshire, UK, 234 p.

Raitzer, D.A. and G.W. Norton. 2009. *Introduction to prioritizing agricultural research for development. In* Raitzer, D.A. and G.W. Norton. (eds.) Prioritizing Agricultural Research for Development. CAB International, Oxfordshire, UK, pp. 1-7.

IPM CRSP Management Entity

Montgomery, K., M.E. Christie, L. Grossman and J. Campbell. 2009. Spatial and gender dimensions of IPM adoption in Uganda. Poster Presentation.

Muniappan, R. 2008. Papaya mealybug, a new invader in Asia. In: IAPPS Newsletter, Number I, January, 2-3, 2009.

Muniappan, R. 2009. Sequel to the article "IPM includes the use of pesticides". In: IAPPS Newsletter, Number II, February, 2009.

Muniappan, R. 2009. A parasitoid to tackle the menace of the mealybug pest of cotton in India. In: IAPPS Newsletter, Number XII, December, 2009.

Muniappan, R., B.M. Shepard, G.W. Watson, G.R. Carner, D. Sartiami, A. Rauf, and M. D. Hammig. 2009. First Report of the Papaya Mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), in Indonesia and India. *Agricultural and Urban Entomology*, (in press).

Muniappan, R., B.M. Sheppard, G. Carner, M. Hammig, Y. Xia, and A. Rauf. 2009. Invasion of papaya mealybug in Asia. Poster presented at the 6th International Symposium on IPM, Portland, Oregon.

Muniappan, R., G.V.P. Reddy, and A. Raman. 2009. *Biological Control of Tropical Weeds Using Arthropods*. Cambridge University Press, 495p.

Muniappan, R., G.V.P. Reddy, and A. Raman. 2009. Biological control of weeds in the tropics and sustainability, *In*. R. Muniappan, G.V.P. Reddy, and A. Raman (eds.). Biological Control of Tropical Weeds Using Arthropods, Cambridge University Press, Cambridge, U.K., pp 1-16.

Muniappan, R., A. Raman, and G.V.P. Reddy. 2009. *Ageratina adenophora* (Sprengel) King and Robinson (Asteraceae), *In*. R. Muniappan, G.V.P. Reddy, and A. Raman (eds.). Biological Control of Tropical Weeds Using Arthropods, Cambridge University Press, Cambridge, U.K., pp 63-73.

Muniappan, R. and F. Steed. 2009. Integrated pest management package for vegetable crops in the tropics. IAPPS Newsletter, Vol. V: 2-4.

Muniappan, R., and F. Steed. 2009. IPM package for vegetable production improves lives in the tropics. Poster presented at the 6th International Symposium on IPM, Portland, Oregon and again at a biological control conference in New Zealand.

Rich, M. 2008. Virginia Tech wins grant for improving food security in Africa. In: IAPPS Newsletter, Number II, 12-13, February, 2009.

Rich, M. 2009. Global pest management program wins international award. Virginia Tech News

Rich, M. 2009. Virginia Tech scientist plays key role in saving the livelihoods of papaya farmers in Sri Lanka. Virginia Tech News

Rich, M. 2009. Virginia Tech garners $30 million from USAID for two global projects. OIRED/Virginia Tech, 10/15/09. Was published as a VT press release and in the fall issue of Global University.

Rich, M. 2009. University program empowers women through gender workshop in Mali. Press release: 7/31/09.

Rich, M. 2009. Virginia Tech's gender program changes lives around the world. Published as a VT press release and in the fall issue of Global University.

Rich, M. 2009. IPM CRSP receives International IPM excellence award. VT press release.

Rich, M. and B. Watts. 2009. The IPM CRSP: transcending global boundaries to increase food security. Poster presented at the 6th International IPM Symposium in Oregon and at the Outreach now conference held at Virginia Tech.

Rich, M. 2009. Feeding the world wisely. Poster presented at the 6th International IPM Symposium in Portland, Oregon.

Rich, M. and B. Watts. 2009. In the developing world: IPM and women, a catylist for change. Presented at the 6th International IPM Symposium in Portland, Oregon.

Rich, M. 2009. OIRED: Contributing to the international scholarship of a world-class university. PPT presentation to the president of Virginia Tech. Delivered by Dr. DeDatta. Contained a secion on IPM CRSP.

Rich, M. 2009. Eggplant grafting transforms life in Gaidghat. USAID website Telling Our Story.

Reddy, G.V.P., R. Muniappan, Z.T. Cruz, F. Naz, J.P. Bamba, and J. Tenorio. 2009. Present status of *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae) in the Mariana Islands and its control by two fortuitously introduced parasitoids. *Journal of Economic Entomology*, Vol. 102 (in press).

Reddy, G.V.P., Z. Cruz, N. Braganza, and R. Muniappan. 2008. The response of *Melitia oedipus* (Lepidoptera: Sesiidae) to visual cues is increased by the presence of food source. Poster presented at the 56th Annual Meeting of the Entomological Society of America, Reno, Nevada, Nov. 16-19, 2008.

Reddy, G.V.P., Z.T. Cruz, F. Naz, and R. Muniappan. 2008. A pheromone-based trapping system for monitoring population of *Cosmopolitus sordidus* (Germar) (Coleoptera: Curculionidae). *Journal of Plant Protection Research*, 48: 515-527.

Reddy, G. V. P., Z. T. Cruz, and R. Muniappan. 2009. Life-history, host preference and establishment status of *Melittia oedipus* (Lepidoptera: Sesiidae), a biological control agent for *Coccinia grandis* (Cucurbitaceae) in the Mariana Islands. *Plant Protection Quarterly* 24: 27-31.

Reddy, G.V.P., Z.T. Cruz, N. Braganza, and R. Muniappan. 2009. Response of *Melittia oedipus* (Lepidoptera: Sesiidae) to visual cues is increased by the presence of food source. *Journal of Economic Entomology*, 102: 127-132.

Shepard, B.M., and R. Muniappan. 2009. Practical Experiences in Advancing IPM in Non-rice Food Crops in Southeast Asia. *In,* Enhancing Vegetable IPM implementation within rice-based system, (eds.). Madonna Casimero and Peter Ooi, *PhilRice Publication* (in press).

Steed, F. 2009. "Magic Traps" Increase Farmers' Profits. USAID website Telling Our Story.

Steed, F. 2009. University scientists warn Asia of widespread invasive pest threat. Virginia Tech News

Zachariades, C., M. Day, R. Muniappan, G.V.P. Reddy. 2009. *Chromolaena odorata* (L.) King and Robinson (Asteraceae), *In*. R. Muniappan, G.V.P. Reddy, and A. Raman (eds.). Biological Control of Tropical Weeds Using Arthropods, Cambridge University Press, Cambridge, U.K., pp 130-162.

APPENDICES

Appendix A – List of Acronyms

ACMV	*African cassava mosaic virus*
ANCAR	Agence Nationale de Conseil Agricole et Rurale, Sénégal
ANOVA	Analysis of variance
APS-OIP	American Phytopathological Society Office of International Programs
ARC-PPRI	Agricultural Research Council- Plant Protection Research Institute
ARISA	Automated Ribosomal Intergenic Spacer Analysis
ATAC	Agriculture Training Advisory Center
AVRDC	Asian Vegetable Research and Development Center/World Vegetable Center
BARI	Bangladesh Agricultural Research Institute
BCMV	*Bean common mosaic virus*
BCRL	Bio-Control Research Laboratories
BIGMP `	Biodiversity and Integrated Gene Managemetn Program
BPTPH	Food and Horticultural Crop Protection Center of West Java
BW	Bacterial wilt
BXW	Banana Xanthamonas Wilt
CABI	Formerly the Commonwealth Agricultural Bureaux International
CABMV	*Cowpea aphid borne mosaic virus*
CBB	Coffee berry borer
CBO	Community Based Organizations
CENTA	Centro Nacional de Tecnificación Agrícola
CERES	Centre de Recherches en Ecotoxicologie pour le Sahel
CES	PhilRice Central Experiment Station
CFC	Couples for Crist
CGIAR	Consortium for International Agricultural Research
CGMV	*Cucumber green mottle mosaic virus*
ChiVMV	*Chilli veinal mottle virus*
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maiz and Wheat Improvement Center
CIMS	Clinic Information Management System
CLB	Cereal Leaf Beetle
CLCuGB	*Cotton leaf curl Gezira betasatellite*
CLCuGVML	*Cotton leaf curl Gezira virus Mali*
CLIMEX	Climate and population modeling software
CLSU	Central Luzon State University
CMDT	Compagnie Malienne de Développement Textile
CMV	*Cucumber mosaic virus*
COI	Cytochrome Oxidase I
CORI	Coffee Research Institute, Uganda
CP	Coat protein
CPB	Cocoa Pod Borer

CRI	Crop Research Institute
CSIRO	Australian Commonwealth Scientific and Research Organization
CWSB	Coffee white stem borer
CYSDV	*Cucurbit yellow stunting disorder virus*
DAG	amino acid motif
DAS	Days After Sowing
DAT	Days After Transplanting
DBM	Diamondback moth
DDIS	Distance Diagnostic and Identification System
Ditlin	Directorate of Horticultural Crop Protection
DR	Dominican Republic
DPV	Direction de la Protection des Végétaux, Sénégal
DSAU	Dnipropetrovs'k State Agrarian University
DWAF	Department of Water Affairs and Forestry
DYMEX	Natural systems modeling software
EACMB	*East African cassava mosaic virus*
EFSB	Eggplant fruit and shoot borer
EIAR	Ethiopian Institute for Agricultural Research
EIQ	Environmental Impact Quotients
ELISA	Enzyme-Linked Immunosorbent Assays
ENSA	Ecole Nationale Supérieure d'Agriculture de Thiès
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
FoSHoL	Food Security for Sustainable Household Livelihoods
FORS	Fish oil rosin soap
FPK	Formasi Pelita Kasih
FR	Fruit rot
FSB	Fruit and shoot borer
FTA	Flinders Technologies in Australia
FUR `	Field Use Rating
FYM	well decomposed compost
GIS	Geographical Information System
GK	Gawad Kalinga/Goodbye Gutom
GKSS	Grameen Krishok Shahayak Sangstha
GPS	Global Positioning System
GTZ	German Technical Cooperation
HAT	Highly aphid transmissible
IAPPS	International Association for Plant Protection Sciences
IARC	International Agricultural Research Centers
IARI	Indian Agricultural Research Institute
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Center for Insect Physiology and Ecology

ICIS	Integrated container-irrigation system
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IDIAF	Instituto Dominicano de Investigaciones Agropecuarias y Forestales
IE	Disease Index
IER	Institut D'Economie Rurale, Mali
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
INERA	l'institut de l'environnement et de researches agricoles, Burkino Faso
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias
INSAH	Institut du Sahel
INSV	*Impatiens necrotic spot virus*
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
ISRA	Senegalese Institute for National Agricultural Research
IYSV	*Iris yellow spot virus*
JAE	Jaringan Arih Ersada
KAP	knowledge attitude and practice
KARI	Kenya Agricultural Research Institute
KAU	Kurgyz Agrarian University
LAC	Latin America and Caribbean
LPS	Lembaga Partanian Sehat
LDMV	Laboratoire de Diagnostic des Maladies Vegetales
MCC	Mennonite Central Committee
MOA	Memorandum of Agreement
MR	Mizing ratio
MSD	Maize streak disease
MSG	Mashed sweet gourd
MSV	*Maize streak virus*
MU/FA	Makerere University Faculty of Agriculture
NaCRRI	National Crops Resource Research Institute
NARC	Nepal Agricultural Research Council
NARI	National Agricultural Research Institute
NARL	National Agricultural Research Laboratories
NARS	National Agricultural Research System
NCIPM	National Center for Integrated Pest Management
NDS	Nature Development Society
NGO	Non-Governmental Organizations
NIFA	National Institute for Food and Agriculture
NPV	Nuclear Polyhedrosis Virus
NSKE	Neem seed kernal extract
OHVN	L'Office de la Haute Vallée du Niger, Mali
OIRED	Office of International Research, Education and Development
OLCD	Okra leaf curl disease

OPIB	L'Office du Périmétre Irrigué de Baguineda
OPLAN Sagip Sibuyas	Information campaign aimed at empowering local onion-rice farmers
OVA	Own Village Advancement
OYCRV	*Okra yellow crinkle virus*
PAB	Program Advisory Board
PBNV	*Peanut bud necrosis virus*
PCI	Participatory Crop Improvement Program
PCR	Polymerase Chain Reaction
PDA	Potato Dextros Agar
PDI	Percent Disease Index
PepGMV	*Pepper golden mosaic virus*
PepMoV	*Pepper mottled virus*
PepYVMV	*Pepper yellow vein Mali virus*
PHYVV	*Pepper huasteco yellow vein virus*
PIB	Polyhedral inclusion body
PILVICSA	Name of Shipping Company
PM	Powdery Mildew
PMMoV	*Pepper mild mottle virus*
PRSV	*Papaya ring spot virus*
PSE	Pesticide Safety Education
PTD	Participatory Technology Demonstration
PVC	Polyvinyl chloride
PVMV	*Pepper veinal mottle virus*
PVY	*Potato virus Y*
PWD	*Passion fruit woodiness virus*
QuEChERS	Quick easy cheap effective rugged safe pesticide residue analysis
RADA	Rural Agricultural Development Authority
RAPD	Random Amplified Polymorphic DNA
RC	Regional Coordinator
RCB	Randomized Complete Block
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
RYMV	*Rice yellow mottle virus*
RYT	Regional yield trials
SeNPV	*Spodoptera exigua nuclear polyhedrosis virus*
SKUS	Samaj Kalyan O Unnayan Shangstha
SLPHT	Sekolah Lapang Pengendalian Hama Terpadu
SOP	Standard Operating Procedure
SSCP	Single Strand Conformational Polymorphisms
SUA	Sokoine University of Agriculture, Tanzania
TaCRI	Tanzania Coffee Research Institute
TBIA	Tissue blot immunoassay
TERI	The Energy and Resources Institute

TEV	*Tobacco etch virus*
TLCV	*Tomato leaf curl virus*
TMV	*Tobacco mosaic virus*
TNAU	Tamil Nadu Agricultural University
ToGMoV	*Tomato golden mosaic virus*
ToGMV	*Tomato golden mottle virus*
ToLCMLV	*Tomato leaf curl Mali virus*
ToMHV	*Tomao mosaic Havana virus*
ToMV	*Tomato mosaic virus*
ToSLCV	*Tomato severe leaf curl virus*
ToYLCrV	*Tomato yellow leaf crumple virus*
TSV	*Tobacco streak virus*
TSWV	*Tomato spotted wilt virus*
TYLCV	*Tomato yellow leaf curl virus*
TYLCV-IL	*Tomato yellow leaf curl virus* – Isreal
TYLCMLV	*Tomato yellow leaf curl Mali virus*
UC-Davis	University of California, Davis
UFO	Ultra Fine Oil
UKZN	University of KwaZulu-Natal, South Africa
UPGMA	Unweighted Pair Group Method with Arithmetic mean
UPLB	University of the Philippines at Los Banos
URL	Universidad Rafael Landivar
USAC	Universidad de San Carlos
USAID	United States Agency for International Development
USDA/ APHIS	US Department of Agriculture, Animal and Plant Health Inspection Service
USDA/ARS	United States Department of Agriculture/ Agricultural Research Service
UVG	Universidad de Valle
UWI	University of the West Indies
VAM	Vesicular-arbuscular mycorrhiza
V-GET	Virtual Geo-referenced Elicitation Tool
WFT	Western flower thrips
WMV	*Watermelon mosaic virus*
WMV2	*Watermelon virus-2*
YMV	*Yellow mosaic virus*
YVM	Yellow vein mosaic
YVMV	*Yellow vein mosaic virus*
ZYMV	*Zucchini yellow mosaic virus*

Appendix B - Participating Institutions

U. S. Universities Government Organizations and NGOs

Clemson University
Florida A&M University
Fort Valley State University
Kansas State University
Michigan State University
Montana State University
North Carolina State University
Pennsylvania State University
Purdue University
The Ohio State University
University of Arizona
University of California-Davis
University of California-Riverside
University of Denver
University of Florida
University of Georgia
University of Minnesota
US Agency for International Development
US Department of Agriculture, APHIS
US Department of Agriculture/ ARS
US Department of Agriculture/ ARS/Horticultural Research Laboratory
US Department of Agriculture, ARS Vegetable Crops Laboratory
US Department of Agriculture, ARS Sustainable Perennial Crops Laboratory
US Department of Agriculure/ Cereals Disease Lab
US Department of Agriculture/ National Institue of Food and Agriculture
Virginia Polytechnic Institute and State University
Virginia State University
Washington State University

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

Action Aid-Bangladesh
Addis Ababa University, Ethiopia
African Union Pesticide Committee (AU-IAPSC)
Aga Khan Foundation, Kyrgyzstan
Agence Nationale de Conseil Agricole et Rural, Sénégal
Agricultural Extension Agency of the District of Cianjur
Agricultural Research Council- Plant Protection Research Institute
Agroexpertos, Guatemala
Ambo Plant Protection Resaerch Center, Ethiopia
Agence Nationale de Conseil Agricole et Rurale (ANCAR)
Australian Commonwealth Scientific and Research Organization (CSIRO)
Bangladesh Agricultural Research Institute (BARI)

Bello University, Nigeria
Bionet
CARE Bangladesh
Caribbean Agricultural Research and Development Institute (CARDI)
CENTA, Ministry of Agriculture, El Salvador
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
Chem-Tica Internacional S.A. (Costa Rica)
Coffee Research Institute, Uganda
Compagnie Malienne de Développement Textile (CMDT), Mali
Consulting Agency ACSA, Moldova
Crop Protection and Plant Biotechnology Lab, Togo
Crop Protection Department, Ecuador
Department of Agriculture, Forestry and Fisheries, South Africa
Department of Agriculture, Local Government Unit of Calauan
Department of Water Affairs and Forestry (DWAF), South Africa
Department of Water and Environmental Affairs, South Africa
Directorate of Horticultural Crop Protection (Ditlin) of the Ministry of Agriculture, Indonesia
Direction de la Protection des Végétaux, Sénégal
Egerton University, Kenya
Environmental Toxicology and Quality Control Laboratory (ETQCL), Mali
Ethiopian Institute of Agricultural Research (EIAR)
FIELD Indonesia
Food and Horticultural Crop Protection Center of West Java (BPTPH)
Grameen Krishok Shahayak Sangstha
Haramaya University, Ethiopia
Harar Agro-technical College
Honduran Foundation for Agricultural Research, Honduras (FHIA)
Indian Agricultural Research Institute, India
International Center for Agricultural Research in the Dry Areas (ICARDA)
International Center for Insect Physiology and Ecology (ICIPE)
International Center for Tropical Agriculture (CIAT)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
International Food Policy Research Institute (IFPRI)
International Institute of Tropical Agriculture (IITA)
International Maize and Wheat Improvement Center (CIMMYT)
International Rice Research Institute (IRRI)
International Potato Center (CIP)
Institut de recherché agronomique de Guinée (IRAG), Guinée
Institut du Sahel (INSAH), Mali
Institute D'Economie Rurale (IER), Mali
Institute of Plant Protection and Ecological Agriculture – PROBIO, Moldova
Instituto Centroamericano de Desarrollo Agropeuario (INERA), Mali

Instituto Dominicano de Investigaciones Agropecuario y Forestales, Dominican Republic
Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Ecuador
Institut Pertanian Bogor (Bogor Agricultural University), Indonesia
Institut Sénégalais de Recherches Agricoles, Sénégal
Ispahani Biotech
Jimma University
Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya
Kenyan Agricultural Research Institute (KARI), Kenya
Kollo Plant Pathology and Nematology Lab, Niger
Kyrgyz Agrarian University
Kwame Nkrumah University of Science and Technology, Ghana
Laboratoire de Defenses des Cultures, Benin
Laboratoire de Phytopathologie, Benin
Laboratoire de Phytopathologie du CDH, Senegal
Laboratoire de Protection des Culture/ENSA, Senegal
Laboratoire de Virologie et de biotechnologie Végétale, Burkina Faso
Laboratoire de Diagnostic des Maladies Vegetales (LDMV), Mali
Laboratoire des Semences, Mali
Le Laboratoire National de la Protection des Végétaux (LNPV)
Lembaga Pertanian Sehat (LPS)
L'institut de l'environnement et de researches agricoles, Burkina Faso
L'Office de la Haute Vallée du Niger (OHVN), Mali
Makerere University, Uganda
Mekelle University, Ethiopia
Mennonite Central Committee (MCC)
Minisry of Agriculture, Jamaica
Ministry of Agriculture, Kyrgyzstan
Ministry of Agriculture and Rural Development, Ethiopia
National University of Tajikistan
National Agricultural Research Institute (NARI), Senegal
National Agricultural Research Organization and Coffee Research Institute, Uganda
National Center for Integrated Pest Management (NCIPM)
National Crops Resource Research Institute (NaCRRI)
Nepal Agricultural Research Council (NARC)
Office of the Irrigated Perimeter of Baguinéda (OPIB), Mali
Oil Palm Research Institute, Ghana
Own Village Advancement-OVA
Pest Control Pvt. Ltd.
Pest Diagnostics Lab, Ahmadu
PhilRice, Philippines
Plant Pathology and Weed Laboratory of DPV, Senegal
Plant Pathology Lab, CRI, Ghana
Plant Protection Research Institute, South Africa
Plant Protection Research Institute, Queensland-Austrailia

Practical Action-Bangladesh
Programme de Developpement de la Production Agricole au Mali, Mali
Rhodes University, South Africa
Rural Agricultural Development Authority (RADA), Jamaica
Reseau African de Developpment de l'Horticulture, Senegal
Safe Agriculture Bangladesh Limited
Safe Agro-Biotech Limited
Sajati Farmer Group of Jorng Sungai sariak Nangari Koto Tinggi
Samaj Kalyan O Unnayan Shangstha
Sam Ratulangi University in North Sulawesi, Indonesia
Sokoine University of Agriculture, Tanzania
Sri Venkateswara University
Tajik Academi of Agricultural Science, Tajikistan
Tamil Nadu Agricultural University, India
Tanzania Coffee Research Institute, Tanzania
Tashkent Institute of Bioorganic Chemistry, Uzbekistan
The Energy Research Institute, India (TERI)
The Farmers Association, Uzbekistan
The World Vegetable Center (AVRDC)
Universidad del Valle, Guatemala
Universidad Rafael Landivar (RUL), Guatemala
Universidad de San Carlos, Guatemala
University of East Anglia, UK
University of Ghana
University of Hyderabad
University of KwaZulu-Natal (UKZN), South Africa
University of Mulawarman, Indonesia
University of the Philippines at Los Baños, the Philippines
University of Queensland, Australia
University of Thies
University of the West Indies, Trinidad
Western Scientific Research Center of Engineering of Agro-Technological Systems
World Cocoa FoundationMahyco Research Center
Zamorano School of Tropical Agriculture

Appendix C – Tables and Figures

Introduction
Table 1. List of Programs, Host countries, Investigators, and Participating Institutions.

Latin American and Caribbean

Table 1. Type and intensity (%) of phytosanitary constrains observed on cocoa in three sites from the coastal plain in Ecuador*. Pichilingue, 2009.

Table 2 Percentage of infected fruits with botrytis and yield of blackberry in dry and rainy seasons in the evaluation of six fungicides with two crop plant management techniques to control botritis. Santa Catalina, 2009

Table 3. Percentage of healthy fruits, yield, production costs and profitability of conventional and *Bacillus* control of anthacnose in Tandapi, Pichincha. Santa Catalina, 2009

Table 4. Reactions to *Fusarium oxysporum* and *Phytophtora infestans,* of segregating plants of five crosses between *Solanum quitoense* (naranjilla) with *S. hiporhodium, S. felinum* and *S. vestisimun.* Santa Catalina, 2009

Table 5. Levels of signification of Diseases Index (IE) and Area Under Diseases Progress Curve (AUDPC) for Black Sigatoka disease on plantain in a cocoa-plantain system. Pichilingue, 2009

Table 6. Population of arthropods found in fallen leaves cocoa, plantain, mixed cocoa – plantain, old mixed farm, and secondary forest in Quevedo area. IPM/CRSP project 2009.

Table 7. Population of arthropods found in intercropping based in Cocoa-plantain. Pichilingue 2009.

East Africa

Table 1. Benefit of IPM Practice over farmers practice.

Table 2: Mean number of wilted plants/plot and yield of each cultivar.

Table 3: The effects of varieties on arthropod pests of tomatoes

Figure 1: Farmers applying mulch (left); a mulched plot (centre); farmers and researchers in discussion on crop development (right).

Figure 2. Trap crop in an experimental field.

West Africa

South Asia

Southeast Asia

Central Asia

Eastern Europe

Table 1: Experiments were established in Kemishtaj (Lushnje region).

Figure 1: Effect of treatment with miticides against two-spotted spider mites in cucumber, Mullet-Tirane, 2009

Table 2: The following botanical pesticides were tested to contol whiteflies.

Figure 2: Effect of microemulsion based on rapeseed oil derivatives on whiteflies (*T. vaporariorum*) on tomato

Figure 3: Whitefly imago mortality in dependence of mixing ratio (MR) Fatty acid potassium salt: fatty acid ethyl esters. V1- MR= 0:100; V2- MR=20:80; V3- MR=50:50; V4- MR= 5:95; V5 MR=50:50+ sodium carboxymethyl cellulose 0.1%, V6- MR=50:50+ Silwet L-77, 0.025% Asterisks indicate significant difference at $P < 0.05$.

Table 3: Yields of Ayaks, Sparta and Hector, with and without soil-applied biological treatments

Figure 4: Yields of cucumbers at test field according to the dates of harvesting in kg.

Table 4: Average weight of plants from three variants

Parthenium

Table 1: *Zygogramma bicolorata* adult feeding, oviposition and larvae development in no-choice tests at Ambo Plant Protection Research Center, Ethiopia

Table 2: Range of feeding of *Z. bicolorata* adults on test plant species in choice test

Table 3: Number of eggs and larvae recorded after 10 days of choice testing on selected test crops

Table 4: Mean stand count of forage species and Parthenium (plants/m^2)

IPDN

Table 1: Samples prepared using the Agdia Plant Sap Collection and Testing Kit and tested for begomovirus and betasatellite infection using PCR.

Thrips-Borne Tospo Virus

Table 1: RT-PCR testing of samples collected from tomato, chilli pepper and cucurbits for the presence of different viruses in Tamil Nadu

Table 2: ELISA testing of tomato samples for the presence of different viruses in Madanapalli area, Andhra Pradesh

Table 3: IYSV transmission rates

Figure 1: RT-PCR detection of TSWV (A) and INSV (B) in single thrips. Lanes 1-5 represent viruliferous thrips and lane 6 represent non-viruliferous thrips. Positive and negative controls are included in lanes 7 and 8, respectively for TSWV (A) and INSV (B). Lane Mr represents molecular weight marker (1 kb Plus DNA ladder, Invitrogen) to estimate the 949 bp and 602 bp fragments, specific to TSWV and INSV, respectively.

Figure 2: RT-PCR detection of TSWV in single thrips. Lanes 1-20 represent viruliferous thrips, lane 21 represent non-viruliferous thrips and lane 22 represents TSWV-infected plant samples that served as a positive control. Lane Mr represents molecular weight marker (1 kb Plus DNA ladder, Invitrogen) to estimate the 949 bp fragment specific to TSWV, represented by an arrow on the right side. Lanes 23-28 represent thrips stored in ethanol and tested for TSWV.

Figure 3: Detection of *Cucumber mosaic virus* (A) and *Peanut bud necrosis virus* (B) by RT-PCR from total nucleic acids eluted from FTA® cards. Field samples were initially spotted on FTA cards and brought to the lab and stored at room temperatures before using for virus diagnosis.

Figure 4: Field incidence of bud necrosis (caused by thrips-transmitted *Peanut bud necrosis virus*) and leaf curl (caused by whitefly-transmitted *Tomato leaf curl virus*) in 15 cultivars/hybdrids. The observations were made based on visual symptoms.

Figure 5: Spatial and temporal spread of tomato spotted wilt disease caused by PBNV in tomato field. Random distribution of infected seedlings (left) serve as a source of inoculum for secondary spread of the disease resulting in clustering of infected plants (right). Each color represents observations at bi-weekly intervals beginning July 14 and ending September 25.

Figure 6: A comparison of unrogueing (A) and rogueing (B) as a strategy to minimize the impact of spotted wilt disease in tomato cultivar US 618 caused by PBNV.

Figure 7: Effect of rogueing on cumulative incidence of PBNV in tomato in all three trials, the cumulative incidence of PBNV is less than 20% in plots (light color bars), whereas the incidence was 50% and above in plots without rogueing (dark colored blocks).

Figure 8: Total yield of tomato in plots with (light bars) and without (dark bars) rogueing.

Table 4: Screening of tomato mutant lines against PBNV under greenhouse conditions

Table 5: Rate of seed transmission of TSV in okra seeds

Insect-Transmitted Viruses

Impact Assessment

Training and Institutional Capacity Development

Management Entitity