IPM CRSP
Annual Highlights

Year 11
2003–2004

Management Entity for the IPM CRSP
Office of International Research,
Education, and Development
Virginia Tech
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VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

IPM CRSP

Integrated Pest Management
Collaborative Research Support Program

Annual Highlights
Year Eleven (2003-2004)

Report Coordinated and Edited by
The Management Entity of the IPM CRSP
Office of International Research, Education, and Development
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IPM CRSP US Institutions

Florida A&M University	Virginia Tech
Montana State University	USDA Veg. Lab.
Ohio State University	U.C.-Davis
University of Georgia	University of Maryland–Eastern Shore
Penn State University	North Carolina A&T University
Purdue University	Fort Valley State University

Host Country Institutions

Guatemala – Agri-lab, ALTERTEC, ICADA, ICTA, UVG	ECUADOR-INIAP
Jamaica – CARDI, Ministry of Agriculture	Eritrea – DARHRD
Mali – IER, OHVN	Albania – PPI, FTRI, AUT
Philippines – NCPC/UPLB, Phil Rice	Bangladesh – BARC, BARI
Uganda – Makerere University, NARO	Honduras - EAP

International Centers

AVRDC – Taiwan	ICIPE – Kenya
CIAT – Colombia	IRRI – Philippines
CIP – Peru	IFPRI - USA

Private Sector

The Kroger Company NOGROCOMA PICO Caito Foods

NGOs/PVOs

CARE-Bangladesh CLADES FHIA – Honduras GEXPRONT, Guatemala ICADA – Guatemala

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IPM CRSP ANNUAL HIGHLIGHTS FOR YEAR 10 (2003- 2004)

Introduction

The IPM Collaborative Research Support Program (IPM CRSP) is a collaborative partnership among U.S. and host country institutions with an emphasis on research, education, training and information exchange. The CRSPs were borne as a result of Title XII, the Freedom from Hunger Act of 1961 which promotes the participation of U.S. government efforts to solve global food and nutrition problems.

The IPM CRSP is a United States Agency for International Development (USAID) funded program which consists of a consortium of IPM disciplines from U.S. universities and host county institutions working collaboratively to reduce 1) agricultural losses due to pests; 2) damage to national ecosystems; and 3) pollution and contamination of food and water supplies. The goals of the CRSP are to develop improved IPM technologies and institutional changes that will increase farmer income, reduce pesticide use and pesticide residues on domestic and export products, improve IPM research and education program capabilities, improve ability to monitor pests, and increase the involvement of women in IPM decision making and program design. A Board of Directors, an External Evaluation Panel and a Technical Committee (made up of site chairs from U.S. universities and site coordinators from host country institutions), guide the IPM CRSP programs. For more information on the IPM CRSP see the website:
http://www.ag.vt.edu/ipmcrsp/index.asp

Working towards the above mentioned goals, the IPM CRSP has the following specific objectives:

- Identify and describe the technical factors affecting pest management.
- Identify and describe the social, economic, political, and institutional factors affecting pest management.
- Work with participating groups to design, test, and evaluate appropriate participatory IPM strategies.
- Work with participating groups to promote training and information exchange on Participatory IPM.
- Work with participating groups to foster policy and institutional changes**.**

The research activities of the IPM CRSP are based on close collaboration between scientists of the participating host countries and U.S. institutions. The participating host country sites of the CRSP during Year 10 included Albania, Bangladesh, Ecuador, Guatemala, Honduras, India, Jamaica, Mali, The Philippines, and Uganda. Among the active partner US institutions are: University of Georgia, Montana State University, Ohio State University, Pennsylvania State University, Purdue University, University of California-Davis and Riverside, University of Maryland - Eastern Shore, North Carolina A&T University, Florida A&M University, Fort Valley State University, USDA Vegetable Laboratory, and Virginia Tech (VT) with VT as the lead and the Management Entity (ME) institution.

This report highlights the activities of the IPM CRSP during the final year of phase II (Year 11). The major portion of the report is devoted to brief summaries of IPM CRSP activities on a regional basis: Africa, Latin America, Asia, Caribbean, and Eastern Europe. This document covers, for each site in a region, a description of the collaborative program, IPM constraints addressed, training and other institution building activities, networking and selected research accomplishments. Since this report covers the final year of the current grant, the report highlights the completion of selected technology development programs and technology transfer programs with emphasis on the latter. Presentations made at the Asian Regional IPM CRSP Workshop in Manila, June 2004 and the IPM CRSP Symposium, Washington DC 5-6 August 2004 and trip reports, PowerPoint presentations and the IPM CRSProgress reports for Year 11 are posted on the IPM CRSP website.

The Site Chairs, host country Site Coordinators, collaborating scientists, and the Management Entity contributed to this report. The Site Chairs and host country Site Coordinators during Year 11 were:

West Africa Site in Mali: Keith Moore, Virginia Tech (Site Chair); Kadiatou Touré Gamby, IER (Site Research Coordinator); Bouréma Dembélé, IER (Site Administrative Coordinator).

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

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

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

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

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

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

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

The following Management Entity personnel contributed to this report:

S. K. De Datta, Associate Provost for International Affairs, Director of the Office of International Research, Education, and Development (OIRED), and Principal Investigator of the IPM CRSP.

E. A. "Short" Heinrichs, Interim Program Director, IPM CRSP, Virginia Tech.

Greg Luther, Assistant Program Director, and Keith Moore, Associate Program Director, IPM CRSP, Virginia Tech.

Debbie Glossbrenner, Financial Services Associate, Virginia Tech.

Overview of the West Africa Site in Mali

Keith M. Moore, Site Chair (Virginia Tech); Kadiatou Touré Gamby, Site Research Coordinator (Institut d'Economie Rurale); Bouréma Dembélé, Site Administrative Coordinator (Institut d'Economie Rurale)

The Collaborative Program

The IPM CRSP research program of the West Africa Site in Mali is carried out through a multi-disciplinary team of collaborating scientists based at four U.S. and five Malian institutions. The four Malian institutions playing a leading role are the agricultural research institution *Institut d'Economie Rurale (IER*), the extension organization *Opération Haute Vallée du Niger (OHVN)*, the toxicology laboratory of the *Laboratoire Central Vétérinaire (LCV)*, and the *Institut Supérieur de Formation et de Recherche Appliqué (ISFRA)* and *Faculté des sciences et techniques (FAST)* of the *Université de Mali*. The West Africa Site in Mali is based at the *IER*. *IER* provides the administrative and research coordination as well as leading scientists for the research activities, contributing expertise in entomology, plant pathology, sociology, economics, and weed science. IPM CRSP collaboration constitutes a key element in *IER*'s long-term plan as defined within the framework of World Bank financing.

The IPM CRSP Project in Mali is supervised by two coordinators. Dr. Kadiatou Touré Gamby, Head of the Fruit and Vegetables Division based at the Sotuba Regional Agricultural Research Center, ensures the scientific coordination of the project, and Dr. Bouréma Dembélé, Scientific Director for IER and Head of the Weed Science Program, ensures the administrative coordination of the project. The coordination of IPM CRSP activities at the research station of Cinzana (CRRA/Niono) is carried out by Mr. Mohamed N'diaye, Entomologist for Millet and Sorghum, and Mr. Sériba Katilé, Plant Pathologist for Millet and Legumes. The IPM CRSP collaboration with *OHVN* is ensured by Mr. Issa Sidibé, Section Head for Research and Development Linkages. *OHVN* works with the private sector in production and marketing of export horticultural crops, including green beans exported to France and hibiscus exported to Senegal, Germany, and the United States. Pesticide residue evaluation activity for exportable products (green beans, tomatoes) financed by the USAID Mission in Bamako is conducted in collaboration with the Toxicology Laboratory of *LCV* under the direction of Dr. Halimatou Koné Traoré. *LCV* is taking the lead in developing a Quality Assurance System for horticultural produce. *ISFRA* provides training for master's students working on IPM CRSP project activities and *FAST* for a Ph.D. student in entomology.

In the United States, four institutions contribute to the collaborative research program: Purdue University, contributing expertise in vegetable IPM (Dr. Rick Foster); North Carolina Agricultural and Technical University, contributing expertise in economics of small-scale producers, including women's horticulture and export markets (Dr. Anthony Yeboah); University of California-Davis, contributing expertise on viral diseases in tomatoes (Dr. Robert Gilbertson); and Virginia Tech, contributing expertise in weed science, pesticide residue analysis, and quality assurance (Dr. James Westwood, Dr. Don Mullins, Dr. Patricia Hipkins and Jean Cobb). Virginia Tech also provides leadership in the person of the Site Chair and Rural Sociologist (Dr. Keith M. Moore).

In IPM CRSP Year 11, the sixth year of Phase II, the Mali site has consisted of participatory on-farm research on tomato virus identification and management, tomato varietal evaluation, and weeds in horticultural production, and training in Farmer Field Schools and Pesticide Safety. In the first years of Phase II research on horticultural export crop pest management, IPM components were developed independently to provide the basis for subsequent combination into packages that address different pest problems simultaneously in peri-urban horticultural crops (green beans, for export; tomatoes, and hibiscus). This research is complemented by on-station research on biological control of the key insect pests, and the conclusion of innovative approaches to management of *Striga* parasitic weed on millet and sorghum, the principal cereal crops of Mali. The second stage of Phase II research focuses on the testing of pest management techniques as integrated packages, and the third stage involves disseminating farmer-tested IPM packages for each horticulture crop in the program. Men and women from thirty villages have participated in village-level FFS (farmer field school) dissemination of the integrated green bean pest management package. Viral problems in tomatoes arising in many producer villages have returned researcher emphasis to stage one priorities for tomatoes: diagnosing the type of viral infection, surveying farmer practices, testing virus resistant varieties and identifying improved plant protection practices.

In addition, these research efforts serve to support the development of a system to reduce pesticide residues on agricultural products through the new Environmental Toxicology Laboratory (ETL) of the Central Veterinary Laboratory (LCV). Rational use of pest control measures may include synthetic pesticides. Consequently, pesticide residue analysis allows for the provision of information on both the current performance and potential improvements of the management system. Combined with on-farm research, pesticide residue analysis aids in the development of IPM technologies for quality produce

verified to meet international food safety standards and residue levels, and ensure the safety of farmers using pesticides.

Technology Transfer

Since its creation, the IPM CRSP has worked with the *OHVN*, which has, as a principal objective, ensuring food security and the diversification of farmer incomes. The *OHVN*'s zone of intervention is the upper Niger River basin, a region where market-garden production is conducted within a short distance of the international airport. Through its Agro Business unit, the *OHVN* ensures the connection between producers and wholesalers, including exporters such as *Flex Mali* and *Mali Première*, both exporters of green beans. During Phase II, green beans were one of the principal export crops towards Europe and this has allowed many small farmers to engage in export agriculture. In *OHVN* zones, green bean production peaked at 124 tons in 2000 with 95 % destined for export and 5% sold on the local market.

The IPM CRSP has collaborated with FAO in the development of didactic materials designed for extension agents and farmers through technical and financial support. For improved diffusion of the technologies developed, the IPM CRSP also collaborates with *PRONAF Mali* (*Project Niébé Africa*), financed by the *International Fund for Agricultural Development (FIDA)* using the Farmer Field School concept. During the past three years farmer field schools have been conducted with both men and women farmers in thirty villages. An evaluation of this approach found that not only were men and women exhibiting improved farming practices and yields, but that their non-FFS participant neighbors were also benefiting.

Pesticide Safety Training is an integral part of the Farmer Field School program. This training has been enhanced with the printing and distribution of 5,000 copies of a pesticide safety booklets for farmers and their families in Bamanan (the local language). Fifty copies of a flip-chart version of this training program (in French and Bamanan) was distributed to IER and OHVN trainers.

The program carried out through the IPM CRSP focuses on the major thrusts of *IER*'s ten-year strategic plan. This work plan is re-examined annually during meetings of the Regional Users Committee (CRU) and the Regional Technical Committee (CTR). At the end of each season, research results are reviewed and plans for the subsequent year are discussed with the farmers.

IPM Constraints Researched

At the beginning of the IPM CRSP Phase II, a hundred green bean farmers were interviewed and agreed that insects and diseases constitute the primary constraints for green bean production from seeding to harvest. Harvest losses were very high, on the order of 4000 kilograms per hectare, amounting to a loss of 160,000 Francs CFA. In addition to the loss in weight, there was also a decline in bean quality caused by insects (such as borers) because the presence of a single damaged pod could result in the rejection of an entire carton destined for export. The principal pest problems for green beans during the past few years have been thrips, whitefly (*Bemisia tabaci*), pod borers, and soil borne diseases.

Among the most frequently cited constraints identified during a recent Participatory Assessment were: (1) the lowering of the water table of the wells which decreases the potential for increasing production; (2) attacks of birds which damage pods causing significant losses of production; (3) the problem of acquisition of certain inputs, such as plastic mulching covers and petroleum jelly; and (4) delay in the payment of the producers. However, more serious has been the weakening of Malian market position in the international market at Rungis, France. Malian exports have dropped over the past couple of years due to poor transportation infrastructure (insufficient space on daily flights and lack of a cold chamber at the Bamako airport). Consequently, one of the major constraints in market chain development is the need for producer coordination and collective investment.

Diagnosis of tomato production constraints was rapidly and more precisely advanced this year using Polymerase Chain Reaction (PCR) technology (a biotechnology technique) through support from the USAID Mission in Bamako. The most important constraint has been two whitefly (*Bemisia tabaci*)-transmitted geminiviruses, the tomato leaf curl virus (TLCV) and the tomato yellow leaf curl virus (TYLCV). The combination of these two viruses has brought whole villages to cease production of tomatoes. Investigation of the nature of these viruses has continued with surveys in new locations and the identification of alternative hosts for these viruses.

A preliminary report on the survey of tomato growers in Mali (Baguineda, Kati, Gao, Koro, and Kayes) has been completed. It gives background on growers' experiences, problems, and reasons for not continuing production if they had stopped. It also describes their perceptions of what the virus problem is and how to recognize it, demonstrating a lot of diversity in farmer perceptions and understanding of the problem. More importantly it was learned that some locations (Baguineda) could adapt to a host free period more easily than others (particularly, Kati).

In garden plots throughout south-central Mali, *Cyperus rotundus* has proven to be the most persistent and devasting weed. Other yield reducing weeds include *Pilea microphylla, Cynodon dactylon, Imperata cylindrica,* and *Commelina benghalensis.* The parasitic

weed *Striga* remains one of the major constraints to millet and sorghum production in sub-Saharan Africa.

Institution Building

The human resource development strategy prepared for the West Africa Site is long term in perspective, assuring a breadth of skills and capacities available for IPM research into the future. This multi-faceted program depends on the University of Mali. Two master's degree students, Daouda Dembélé, in weed science, and, Sidiké Traoré, in entomology have recently completed their training. Moussa Noussourou is continuing his work in entomology at the University of Mali on his Ph.D. program (Rick Foster, Entomology/Purdue, and Bob Gilbertson, Plant Pathologist/UC-Davis are his advisors). Safiatou Dem completed her masters degree in Biochemistry at Virginia Tech under the direction of Don Mullins, entomologist.

The Farmer Field School Program continued on green bean production for export and involved the training of 200 men and 190 women farmers in 9 villages led by previously trained IER and OHVN FFS trainers and farmer-trainers. In addition, 293 women and 373 men from 12 villages were trained in Pesticide Safety.
Short-term training in the U.S. involved Samba Soumaré (sociology) for two weeks at Virginia Tech to work on quantitative data analysis methods for the tomato growers' survey. In November 2003, two ETL scientists (Halima Traoré and Fousseni Diallo) participated in a three-week laboratory training session at Virginia Tech. Specific training activities included hands-on extraction and analysis of chlorinated acid herbicides, synthesis of reagents needed for the previous chemical group, fire safety class (classroom and hands-on experience with a controlled fire), demonstration of laboratory cholinesterase method and "lesson's learned" from the testing program at Virginia Tech.

Institutional strengthening is reinforced by frequent opportunities for one-on-one collaboration in the planning and conduct of research activities. Eight trips were made to Mali by U.S. scientists. Collaboration involved issues including a survey to investigate establishing a TYLCV host-free period (Dr. Moore), assessment of weeds in peri-urban horticulture (Dr. Westwood), tomato disease investigations (Drs. Gilbertson and Foster), toxicology laboratory development and pesticide safety training (Drs. Mullins, Hipkins, and Cobb), and quality control assurance and pesticide usage and application (Dr. Hipkins).

On the Malian side, three visits were made to the U.S. Dr. Gamby and Bouréma Dembélé visited the U.S. for the IPM CRSP Symbosium, Globalizing IPM through Participatory Research: Lessons from the IPM CRSP. Samba Soumaré worked on quantitative methods for social survey analysis applying SPSS (the Statistical Package for the Social Sciences).

The Malian Government supports IER's IPM Program by paying salaries of the researchers and technicians, and supplying equipment and supplies (vehicles, offices, laboratories and experimental fields, etc.). In addition to this material support, the IPM CRSP has made an important contribution to research in Mali by establishing and maintaining a strong multi-institutional and pluri-disciplinary team in collaboration with farmer associations and exporters.

Networking

The core mechanism for in-country diffusion of research results depends on the relationship between IER and OHVN in the peri-urban horticultural regions. This relationship is built on the work of IER/OHVN liaison officer, Issa Sidibe. The network extends from field agents in the peri-urban horticultural regions encountered frequently in the field (by Pat Hipkins, Mme Gamby, and Moussa N'diaye).

IPM CRSP research results have been presented at the Regional Technical Committee (CTR) meeting at Sotuba (May 2004), at the Regional Users Committee (CRU) meeting at Sotuba (March 2004) and to the IER Program Committee (June 2004).

Dr. Hipkins served as a resource person for the dissemination of the 10-lesson set of the Pesticide Safety Education training program regarding the content, as well as active teaching and learning techniques, which helped the IER and OHVN team of trainers "fine tune" their presentations and activities. The materials they acquired at "train the trainer" sessions in previous years as well as the delivery and evaluation of instructional, lesson plans and hands-on demonstration materials were effectively used. Topics presented at the training session included an overview of pesticide safety, small group workshops, and a demonstration of pesticide handling and exposure.

Regional networking has continued with Dr. Traoré maintaining contacts with Dr. Abdoulaye Niassy, DPV/Sénégal and with Dr. Ardjouma Dembélé of LABECO in Ivory Coast, particularly in terms of developing improved supply sources for laboratory chemicals. Dr. Hipkins met with USAID/Mali's new AEG team members and their CLUSA implementers to discuss current and future capacity building efforts in Mali.

Research Accomplishments

Weed Control Strategies for Tomato and Green Bean Production

Research this year focused on the use of potash solutions for weed control. Last year, the use of burned mulch material was studied. Burning crop residues on the soil surface was not effective as a sole weed control method, but when combined with use of mulch it decreased weed numbers and increased yields relative to the current farmer practices.

- Potash solutions can be used as cheap, locally-available contact herbicides for general weed control. Use of an adjuvant affects efficacy and species selectivity.

Management of Tomato Diseases

A DNA probe and primers have been developed to facilitate identification of the tomato leaf curl virus (TLCV) and the tomato yellow leaf curl virus (TYLCV) in both vectors (whiteflies) and in host plants. New locations and host plants are being explored.

A solanaceous crop-free period has been developed and implemented during July-August in Baguineda, Mali as a key component of an IPM strategy for tomato leaf curl disease (another location without a host-free period is serving as a control). Monthly PCR assays of whiteflies collected from different locations in Baguineda are being used to assess the relative success of the host free period in reducing the incidence of tomato leaf curl viruses.

Tomato germplasm with geminivirus resistance were tested last year including varieties from Heinz Seed Co., Seminis Seed Co. and AVRDC. Those varieties demonstrating high yields and virus-resistance have been obtained and disseminated to farmers in Baguineda as the second component of the IPM program for tomato leaf curl viruses. Additional promising sources of traditional resistance (tomato lines/cultivars) to tomato leaf curl viruses in Mali are being identified that could be used in a traditional breeding program. A strategy for genetic engineering of a tomato variety for resistance to Mali tomato geminiviruses based on the sequences of the viruses identified in Mali to date has been initiated.

An in-depth survey of tomato growers in Baguineda, Kati, Gao, Koro, and Kayes confirms findings from the preliminary survey of producers in Baguineda. Farmers were prepared to make adjustments in their production systems to combat the TLCV. The analysis suggests, however, that the farmers could not distinguish between the geminivirus (cause of the disease) and the whitefly (vector of the disease). In addition, implementation of the host-free period may be successful in Baguineda, because of traditional lapse in production during the months of July and August. However, establishing a host free period at Kati where production occurs year round may be more difficult. Clearly, training is in order.

Farmer Field Schools

Currently, farmer field schools (FFS) for both men and women on green bean farming have been implemented in the Kati region just outside Bamako. This program has benefited from the collaboration of IER researchers and OHVN field agents.

A total of 390 farmers (190 women and 200 men) from 9 villages were trained in Farmer Field Schools on green bean pest control.

Expanded Pesticide Safety Education

In a collaborative effort between IER, OHVN and Virginia Tech's Pesticide Safety program a pesticide safety booklet was developed, translated into Bamanan, reviewed, produced and distributed to farmers and to agencies working with rural literacy programs. To accompany this booklet, trainers were provided with a "flip chart" version of the book in large format for trainers to use with groups. One side of the book has large images, which the farmers see; the reverse has a smaller image with text in Bamanan and French for trainer use. OHVN and IER trainers demonstrated their mastery of the training materials and lessons learned during last year's training of trainers program.

- IER and OHVN distributed 5,000 copies of pesticide safety booklets for farmers (in Bamana) and more than 50 pesticide safety flip charts in large format for trainers to use in group training sessions.
- A total of 666 farmers (293 women and 373 men) from 12 villages were trained in pesticide safety skills.

Environmental Quality Laboratory

Technical training of the staff at the Environmental Quality Laboratory (EQL) continued with specific training activities including hands-on extraction and analysis of chlorinated acid herbicides, synthesis of reagents needed for the previous chemical group, fire safety class (classroom and hands-on experience with a controlled fire), demonstration of laboratory cholinesterase method and "lesson's learned" from the testing program at Virginia Tech.

- In May 2004, Mme Safiatou Dem completed her MS Degree in the Life Sciences majoring in Entomology with specific training in environmental chemistry.

Her thesis was entitled "Environmental Study of Pesticide Residues in Soil and Water From Cotton Growing Areas In Mali. She has returned to the ETL and resumed her position as a lab technician.

List of Publications

Dem, S B., D. Mullins, J. Cobb, P. A. Hipkins, K. M. Moore, H. Traoré, K. Gamby, and I. Sidibé 2003. Environmental study of pesticide residues in soils and water in cotton growing areas in Mali. National Pesticide Stewardship Alliance Annual Conference. Tucson, AZ October, 2003.
http://www.npsalliance.org/Conf2003/PDF2003/SDem.pdf

Dem, Safiatou Berthe. 2004. MS Life Sciences. Entomology Department, VPI&SU. Thesis title: Environmental Study of Pesticide Residues In Soils And Water In Cotton Growing Areas In Mali. 141pp.

Jenkins, D. A., F. V. Dunkel, and K.T. Gamby. Storage Temperature of Neem Kernel Extract: Differential Effects of Oviposition Deterrency and Larval Toxicity of *Callosobruchus maculatus* (F.) (Coleoptera Bruchidae). Environmental Entomology 32(6):1283-1289 (2003).

Martin, M. S., Goble, A. R., N'Diaye, M., Dembélé, B., Gamby, K. Mullins, D., Fell, R., and Westwood, J. H. 2004. Characterization of foliar-applied potash solution as a non-selective herbicide in Malian agriculture. 4th International Weed Science Congress Abstracts. p. 87. submitted to Crop Protection.

Soumaré, S., and K.M. Moore. 2004. Experience et perception des producteurs de tomate: la virose de la tomate au Mali. research bulletin, CRRA/Sotuba, Institut d'Economie Rurale. p. 14.

Overview of the East Africa Site in Uganda

J. Mark Erbaugh, Site Chair, The Ohio State University
Samuel Kyamanywa, Site Coordinator, Makerere University
George Bigirwa, Deputy Site Coordinator, NARO/NAARI

The Collaborative Program

The IPM CRSP Uganda Site is a collaboration of Makerere University Faculty of Agriculture (MU/FA), the Ugandan National Agricultural Research Organization (NARO), the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) Extension Service, participating farmer NGO groups and scientists from IPM CRSP USA Institutions. The program in Uganda operates under a Memorandum of Understanding with Makerere University Faculty of Agriculture (MU/FA). Dr. Samuel Kyamanywa, Chair of the Department of Crops Sciences at MU/FA is the Uganda Site Coordinator. He is directly linked to the National Agricultural Research Organization (NARO) through the Deputy Site Coordinator who is appointed by the Acting Director General of NARO, Dr. Otim-Nape. Dr. G. Bigirwa is the Deputy Site Coordinator, and he is also leader of NARO's Maize Research Team. The IPM CRSP collaborates with research scientists from four NARO research institutes: Kwanda Agriculture Research Institute (KARl), Namulonge Agricultural and Animal Research Institute (NAARI), Serere Agricultural and Animal Research Institute (SAARI), and the Coffee Research Institute (CORI).

The IPM CRSP team in Uganda consists of six co-PIs and graduate students from MU/FA, six co-PIs from NARO, and three extension agents, representing six separate disciplines. Collaborating with Uganda are eight USA-based co-PIs, representing four disciplines from four universities: The Ohio State University, Virginia Tech, Fort Valley State University and Penn State University. This multi-institutional and multi-disciplinary program is coordinated by the Site Chair, Dr. Mark Erbaugh, The Ohio State University. Site management is facilitated by frequent contact between the Site Chair and Coordinator, and all co-PIs maintain regular communication on individual research activities with respective collaborating scientists in Uganda. The Site Coordinator administers the implementation of field research activities which are facilitated by extension agents and farmer associations at research sites in Iganga, Kumi, Mpigi, Mayuge, and Pallisa districts. Linkages with local extension agents have facilitated the implementation of a farmer participatory approach to integrated pest management (PIPM) technology generation and transfer by providing scientists co-PI' s and graduate students linkages with local communities and farmer groups, helping to arrange and conduct on-farm research, contributing to farmer field training schools, and helping to coordinate graduate student field research activities.

Planning and support for IPM CRSP activities in Uganda involved communication and collaboration with USAID/Kampala, the IDEA Project, the Rockefeller Foundation through the Forum on Agricultural Resource Husbandry, germplasm exchanges with AVRDC, IlTA, ICRISAT/Malawi, and CIMMYT/Harare, and a continuing interaction with ICIPE. The collaboration with ICIPE this year focused on identifying parasitoids of the groundnut leaf miner (*Aroarema modicella*). Co-PI Dr. R. Pratt, continued to coordinate research efforts to determine molecular marker-assisted selection procedures for improvement of multiple maize disease resistance with scientists from CIMMYT/Harare, the Grain Crops Research Institute in South Africa and NARO's Maize Research Team. This collaborative effort was the recipient of a special bio-technology research award from the IPM CRSP ME. Additionally, Dr. Pratt was the recipient of National Science Foundation travel award to attend the African Crop Science Conference in October, 2003, and to expand collaborative links with other regional scientists. USAID/Kampala continued providing funding support with a match from the IPM CRSP ME to investigate the etiology, epidemiology and integrated management of coffee wilt *(Fusarium xylarioides).* Finally, the Rockefeller Forum provided opportunities to cost share outreach activities for two MU/FAF graduate students.

IPM Constraints Addressed

The primary IPM constraints addressed at the Uganda Site are 1) poor linkages between research scientists and farmers; 2) A lack of alternatives to multiple applications of chemical pesticides, particularly for important legume crops such as groundnuts and cowpea in Eastern Uganda, but also for tomatoes; 3) research fragmentation caused by insufficiently integrated research activities of multiple institutions and disciplines; and 4) limited distribution and dissemination of IPM technologies. In order to address these constraints the Uganda Site implemented a participatory approach to the conduct of IPM research. The initial field PA held with farmers at research sites in Iganga and Kumi Districts in 1995, and now verified by two baseline surveys, identified priority crops and pests. This helped orient research to solving farmer problems – demand-driven activities. Subsequent activities, including farmer field pest monitoring, farmer open days, and on-farm trials, added to or amended pest and disease

priorities. Priority insect pests and diseases by crop being addressed in the IPM CRSP research program are as follows: **Cowpea**, cowpea aphid *(A. craccivora)*, cowpea flower thrips *(Megalurothrips sjostedti)*, *Maruca* sp. pod borers, and *M vitrata*, pod sucking bugs and the bruchid beetle *(Callosbruchus chinesis);* **Groundnuts**, groundnut rosette virus disease *(Arachis hypogaea* L.), aphids *(Aphis craccivora* Koch the vector of rosette disease), Cercospora leaf-spot *(Cercospora arachidicola)*, the groundnut leaf miner *(Aroarema modicella)*, foot rot *(Sclerotium rolfsii)* and thrips *(Thrips palmi* Kamy, *Frankiniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus);* **Maize**, stalk borer *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae), Gray leaf spot (*Cercospora zeae-maydis)* and termites *(Macrotermes, Pseudacanthotermes* and *Microtermes);* **Sorghum**, stalk borer *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) and the parasitic weed, *Striga;* **Tomato**, late blight *(Phytophthora infestans)*, bacterial wilt *(Ralstonia solanacearum)* and thrips *(Thrips tabaci* and *Frankliniella sp.);* **Maize and Groundnut** moulds and mycotoxins *Aspergillus*, *Fusarium*, *Rhizopus* and *Penicillium* species; and, **Coffee**, coffee wilt *(Fusarium xylariodes* (telemorph = *Gibberella xylarioides*). Researcher interactions with farmers also suggested component technologies that have been integrated into trials. Local farmers suggested the interplanting of *Celosia argentia* with sorghum, and the use of cotton in rotation, to reduce the incidence of S*triga;* and, the use of several locally available bio-rational products in post-harvest storage to reduce bruchid damage.

Year 11 work plan activities were also designed to be closely aligned with USAID/Kampala's Strategic Objective 7: Expansion of Sustainable Economic Opportunities for Rural Sector Growth. The rationale behind this objective is that increasing agricultural productivity in Uganda is the primary strategy for reducing poverty and that this must be realized from a sustainable use of natural resources. The goals and objectives of integrated pest management are well suited to complement and support this rationale. Among the broad-based priority activities suggested were transfer of improved agricultural technologies to farmers, promoting and improving Uganda's capacity to expand production quantity and quality of key commodities, utilization of biotechnology, and assessing impacts.

Building on the participatory approach to IPM that delineated farmer driven priorities early in the project's history, research activities to refine and disseminate IPM strategies for cowpea, groundnuts, and sorghum to farmers were scaled-up. Corresponding with this topical area were activities to promote management of post-harvest pests of cowpea, enhance the activity of natural enemies to provide sustainable management of groundnut and cowpea pests, and a classical biological control effort to manage groundnut leaf miner. IPM research activities on tomato included grafting tomatoes on wilt-resistant indigenous rootstocks, a best practices package determined with farmers, and demonstrated to new farmer groups in Mpigi District. The development of IPM practices for legume and horticultural crops is important because the production of these crops is associated with excessive use of pesticides. Activities undertaken to improve Uganda's capacity to support production of export and locally marketed crops were: 1) IPM research and training activities to support hot pepper growers affiliated with HORTEXA (Horticultural Export Association); pest and disease diagnostic capacity building at Makerere University through short-term laboratory-oriented training programs at the Ohio Agricultural Research and Development Center (OARDC); demand-driven Pesticide Use and Safety training programs provided to hot pepper growers and National Agricultural Advisory Service providers; and, developing and disseminating improved maize quality standards as established by the Uganda National Bureau of Standards (UNBS).

In support of USAID/Global Bureau and bi-lateral Mission initiatives to support the application of biotechnology to alleviate hunger and poverty, IPM CRSP Uganda Site work focused on: developing simple sequence repeat (SSR) molecular markers to select QTLs conferring resistance to multiple foliar diseases of Quality Protein Maize in collaboration with scientists from Uganda, CIMMYT, OSU, and a Ugandan graduate student at OSU. Several biotechnology applications were applied to support the IPM CRSP Uganda Site's response to the integrated management of coffee wilt (*Fusarium xylarioides*). Coffee remains as Uganda's most important export crop and the coffee wilt effort has been supported by USAID/Kampala with a match from the IPM CRSP ME. Finally, Year 11 activities continued with socioeconomic analyses that address impact assessment, adoption and market analysis.

Institution Building

One of the main contributions to institutional capacity building by the IPM CRSP Uganda Site has been human resource development. Graduate student training at Makerere University has facilitated domestic and international institutional collaborations and contributed to research output. Twenty three Ugandan graduate students have completed their MS degrees. The following individuals completed their M.S. programs this year: Mrs. M. Amujal, Mr. Eric Kagezi, Ms. M. Ochwoh, Mr. Alfred Alumai (M.S. degree from OSU – in-country research supported by IPM CRSP) and Mr. T. Munyuli. Two individuals are finishing their Ph.Ds: Mr. Godfrey Asea's research project at OSU is titled: "Genetic Characterization and Marker-Assisted Selection for Multiple Disease Resistance in Maize" and Mr. A. Kaaya, who completed his course work at Virginia Tech,

is working on his dissertation titled: "Identification and Incidence of Mycotoxins on Maize and Groundnuts" at Makerere University. Two Ugandan scientists completed three-month biotechnology training programs in the USA: 1) Dr. Africano Kangire, NARO/CORI spent three months at Ohio State University in the laboratory of Dr. Sally Miller. During his training Dr. Kangire carried out further studies on the characterization of *Fusarium* spp. from coffee trees in Uganda with coffee wilt disease. These studies included mating type analysis of the Fusarium isolates, DNA extraction and sequencing of select genes for Fusarium taxonomy, and analysis of sequence information using specified databases. Dr. Kangire also worked with Dr. David Geiser of Penn State University, a Fusarium taxonomist and collaborator on the project. Upon returning to Uganda, Dr. Kangire initiated pathogenicity studies using these isolates; 2) Dr. Geoffrey Tusiime carried out a 2-month training program in bacteriology and diagnostics at Ohio State University in Dr. Sally Miller's lab. Dr. Tusiime participated in diagnosis of vegetable samples and was trained in standard diagnostic techniques including microbiological assays, use of selective media, immunoassays and PCR. He also began studies to characterize the strains of *Xanthomonas campestris* pv. *musacearum*, causal agent of bacterial wilt of banana, by molecular fingerprinting.

There were nine trips made to the Uganda Site this year by USA based co-PIs. Drs. Pratt, Erbaugh and Felix and OSU graduate student, Godfrey Asea, attended the All African Crop Science Society meetings in Nairobi in October, 2003. Dr. G. Luther went to Uganda to continue his collaborative effort with Dr. Kyamanywa and a Makerere University graduate student on the identification and biology of beneficial insects on cowpea and groundnuts. In early January and March, the Site Chair, Dr. Erbaugh went to Uganda to implement both biological and socioeconomic baseline studies of hot pepper producers, review implementation of year 11 work plan activities, hold discussions with USAID/Kampala, and advise other dissemination activities. He was joined by Dr. Taylor, Virginia Tech, who put together a series of economic impact studies. Dr. G. Mbata, Fort Valley, came to Uganda to collaborate with Drs. Kyamanywa and Agona on field management of cowpea bruchids using pheromone baited traps. Dr. Herman Warren, Virginia Tech, went to Uganda to supervise the dissertation research activities of Mr. Kaaya. Dr. Erbaugh returned to Uganda to attend the final annual report presentation and writing workshop in early September. This was followed by Dr. Pratt and graduate student Asea going to Uganda to implement a two day workshop on marker-assisted maize breeding with thirty-five scientists from MU/FAF, NARO, and invited scientists from the Kenyan Agricultural Research Institute (KARI).

Networking

Networking is facilitated by the functional links between the Site and Deputy Site Coordinators and their respective organizations, and close communication with the Site Chair. These linkages are reinforced by visits made by USA-based co-PIs to the Director General of NARO, the Dean Faculty of Agriculture and Directors of participating research institutes. Preliminary research results are presented by co-PIs and graduate students at annual research meetings held in Uganda. This year, the annual meeting was held in March in Entebbe. Visits by the Site Chair always include update meetings with USAID/Kampala and USAID sponsored projects. Networking is also facilitated by Uganda Site co-PIs attending IPM CRSP annual meetings in the USA. This year, the Site Coordinator, Dr. Kyamanywa, and the Dean of the Faculty of Agriculture at Makerere University, M. Bekunda attended the IPM CRSP Final Symposium held in Washington, D.C. in August. Regional networking is conducted via electronic communication, research collaborations, and participation in professional societies and symposia. Formal research collaborations with ICIPE and the Rockefeller Foundation focus on mutual contributions to graduate student training and advising. Both the Site Chair and Coordinator made visits to ICIPE this year and ICIPE investigator, Dr. Charles Omwega, visited Uganda. Direct communication between Uganda co-PIs and USA co-PIs have resulted in germplasm exchanges with AVRDC, IITA, CIP, ICRISAT, and USDA potato research program, and CIMMYT /Harare. Functional links with extension agents and farmer NGO groups are maintained to promote IPM and technology transfer. Regional networking this year was promoted through the participation of co-PIs and graduate students in the All African Crop Science Society, the collaboration with ICIPE, and the marker assisted maize breeding workshop.

Research Highlights

Biological control of cowpea pests: Earlier work conducted by the IPMCRSP in Eastern Uganda indicated that pesticide applications significantly reduced natural enemies of cowpea, and that there was need to increase their abundance. In year eleven, activities were carried out to assess different methods of enhancing native natural enemy populations in cowpea fields. The results indicate that:

- Abundance of parasitoids was influenced by different methods of chemical application. The number of parasitoids of cowpea aphids was 17-fold higher in cowpea plots where pesticides were applied in strips than in plots where pesticides were uniformly applied. Similarly, parasitoids of thrips and pod borers were 10 fold higher in cowpea plots where pesticides were applied in strips than in uniformly

sprayed ones.

- The yield of cowpea plots where pesticides were applied in strips was not significantly different from those plots which were uniformly sprayed with pesticides. The results suggest that spraying in strips can conserve indigenous parasitoids of cowpea.

Biological control of groundnut leafminer: The groundnut leafminer *Aproaerema modicella* was identified as an exotic pest of groundnut. Studies are on-going to explore classical biological control for management of groundnut leaf-miner in Uganda. The studies have shown that:

- Only one larval parasitoid (*Bracon* sp.) was recorded from *A. modicella.*
- Parasitism level between 3% - 9%, depending on the locality, was recorded, which is low. The findings suggest that, *A. modicella* being a new pest, has very few parasitoids--making it a good candidate for classical biological control.

An Assessment of the Market Acceptability of Split Cowpea in Kumi district: Cowpea grains are susceptible to bruchids (*Calosobruchus maculatus*) and other pests during storage. Trials conducted last year demonstrated that splitting cowpea controls bruchid infestations by denying them an oviposition site. A prolonged storage period benefits farmers with a better price through product availability during the off-season. Cowpeas are split using a traditional grinding stone which limits quantities processed and stocked, and affects uniformity and quality of the split product. Data for the study were obtained from market stalls in Kumi.

- Split cowpeas fetched a higher marketing margin than un-split cowpeas from the vendors (Shs 250 per kg compared to 150 Shs per kg. for un-split cowpeas).
- Though fetching a higher marketing margin, the quantities of split cowpeas sold per week were lower than quantities of un-split cowpeas sold (33 kg per week compared to 42 kg per week). This implies low demand and acceptability.
- Two key attributes of split cowpea preferred by consumers: the shortened cooking time and the ability of the split product to store for longer periods. Two marketing channels exist: farmers selling directly to consumers and traders buying from farmers and stocking in the markets for sale to consumers.

Dissemination of integrated *Striga* management technologies among small-scale rural farmers in Eastern Uganda: Four improved *Striga* management technologies were disseminated to 240 farmers in eastern Uganda through participatory on-farm demonstrations.

- Growing sorghum in rotation with cotton and cowpea reduced Striga seed load in the soil by 78%, reduced its emergence by 48% and increased sorghum yield by 14%.
- Intercropping sorghum with *Celosia argentea* reduced *Striga* emergence by 60% and increased sorghum yield by 32%.
- Applying nitrogen fertilizer on a *Striga* tolerant sorghum variety, Seredo reduced *Striga* emergence by 35% and increased sorghum yield by 83%.
- Applying nitrogen fertilizer on a *Striga*-tolerant sorghum variety, Seredo, intercropped with Silver leaf desmodium reduced *Striga* emergence by 68% and increased sorghum yield by 26%.
- Three-hundred *Striga* management brochures have been distributed to participating farmers, Agricultural Extension workers of Kumi and to Technicians at Serere Agricultural and Animal production Research Institute (SAARI).
- Intercropping sorghum with trap crops gives higher net benefits compared to fertilizer use. Seredo/Celosia argentea intercrop gives the highest net benefit of U.shs. 718,500 per ha followed by Seredo/cowpea with net benefit of U.shs. 538,950 per ha.
- Intercropping Seredo with *Celosia argentea* gives marginal returns of about 60 times more than Seredo/Cowpea intercropping, while Seredo/Cowpea intercropping gives marginal returns 8 times better than farmer practice (local sorghum variety, broadcasted, no intercropping).
- Though suppression of *Striga* is highest when Celosia is intercropped with sorghum, farmers prefer to intercrop sorghum with cowpea due to other benefits besides suppression of *Striga* such as dietary and market diversification.

Integrated Disease Management for Maize:

- Linkage of molecular markers to resistance genes (QTLs) for gray leaf spot were identified on chromosomes 2 and 4 of resistant South African maize inbred VO613Y. A publication came out in the journal Crop Science.
- Cooperative research with CIMMYT (Zimbabwe) and NARO (Uganda) yielded data characterizing the host responses of segregating maize lines (CML202 background) to maize streak virus (MSV) and northern corn leaf blight (NCLB), respectively. Combined with OSU data for gray leaf spot resistance and agronomic traits, lines with resistance to multiple diseases were made and advanced in the greenhouse.
- Molecular markers with linkage to resistance genes (QTLs) to MSV, NCLB, and GLS were identified for marker-assisted selection by Ph.D. student Godfrey Asea.
- The First East African IPM CRSP Molecular Marker Workshop was held at Makerere University in Kampala, Uganda. Co-organizers were Rich Pratt (OSU) and Richard Edema (Makerere). Thirty-five scientists participated.

An alternative approach to increasing tomato production by reducing incidence of bacterial wilt through grafting: Studies were conducted in Mpigi and Luwero districts to promote tomato grafting in an effort to control bacterial wilt (*Ralstonia solanacearum*) and to assess the impact and acceptability of grafting technique by farmers.

- All ungrafted tomato plants died before flowering, probably due to the prevailing unfavorable weather conditions and partly due to the bacterial wilt.
- The plants on *S. incanum* rootstock showed more tolerance to harsh weather conditions than those on *S. indicum* subsp. *Distichum* rootstock.
- Farmers in various locations are becoming interested in tomato grafting techniques and some are trying it individually on their own farms.
- The integration of grafting method into an IPM system has excellent potential to improve tomato production in Uganda.

Assessment of major insect pests and disease status for Scotch Bonnet pepper in Mpigi district: Production and biological baseline surveys of Scotch Bonnet hot pepper production in Mpigi District indicated that the 100 sampled producers were small, farming 4.3 acres with an average of one acre in hot pepper production; 90% were men; with 8 years of education (one year of post-primary education); and averaged 40 years of age. Additionally, excessive pesticide use was indicated: 85% of the sample were spraying pesticides on this crop 12 times or more; 41% were spraying 24 times or more; and 9% were spraying 48 times or more over the course of a six month growing season.

- Farmers were using various insecticides and fungicides in cocktails but the various spray regimes they were following had differential effects on the prevalence of the insect pests and diseases.
- The major insecticides used by farmers in management of insect pests included Fenkill (a.i. – fenvalerate), Rocket (a.i. – fenvalerate), Sulmathion (a.i. – malathion), cypermethrin, and dimethoate. The major fungicides used include Milraz, Dithane M45, Toplite (a.i.- trophanate methyl and maneb). Farmers were not aware of an appropriate miticide to use in management of mites.
- Major insect pests of Scotch bonnet pepper in Mpigi district were identified as: Fruitflies (*Dacus* spp.), whiteflies (*Bemisia tabaci*), thrips, (*Frankliniella* spp.), and bollworms (*Helicoverpa armigera*); mites (not a true insect).
- The major diseases observed included Anthracnose (caused by *Colletotrichum* spp.), and viruses.
- As observed by CABI scientists (CABI Crop Compendium, 2003), all of the above identified pests are polyphagous, therefore, their management is difficult without the knowledge of integrated pest management principles. Almost all the farmers were not aware of the IPM principles.

Development of insect pest and plant disease diagnostic services for exporter, farmers and scientists: Lack of institutionalized diagnostic service in Uganda is a serious constraint to pest management and export agriculture in the country. Therefore a diagnostic clinic is being established in the department of Crop Science Makerere University. The following activities have been accomplished:

- Office space for the diagnostic clinic has been established and furnished.
- Specimen boxes have been purchased.
- Scientist, Dr. Geofrey Tusiime, underwent a three month training program, at Ohio State University, in diagnosis of bacterial diseases using biotechnological approaches, and in the running of a plant diagnostic clinic.
- Documents to be used in handling and processing specimens have been developed and printed.
- Brochures for advertising the services have been published.

Pesticide application and safety training course for producers, pesticide dealers and exporters: Lack of awareness of the dangers associated with pesticide use is the main cause of pesticide abuse in Uganda. Therefore, training pesticide dealers, farmers and exporters in pesticide application and their safety was viewed as one way of reducing pesticide misuse. The following activities were carried out:

- A ten-day training course in Pesticide Safety Application was conducted in which 36 pesticide dealers and 4 farmers involved in export of pepper participated.
- In partnership with the I@mak.com project, 15 pesticide farmers field schools were established in three districts of Uganda; 5 schools per district. Through this process a total of 450 farmers were trained in safe pesticide application and IPM.
- Brochures on pesticide dangers and safe pesticide application are of being produced.

Improvement of maize grain quality and marketing through adoption of appropriate post-harvest technologies: Studies were carried out to determine the factors that negatively affect the grain quality and to identify and validate grain quality mitigating post-harvest technologies. Major findings:

- Insects, rodents, moulds and aflatoxin contamination have remained major agents that negatively affect grain quality in Uganda.
- Delayed harvest of maize up to more than 4 weeks after physiological maturity was found to be practiced by all farmers in Mayuge district and, this has been found to be another factor that promotes contamination of maize by loss agents.
- Delayed harvest of maize by three weeks after physiological maturity increased insect damage by three times; mould (*Aspergillus, Fusarium* and

Penicillium spp) infection by two times; and aflatoxin contamination by four times.

- Farmers should harvest maize after two weeks of physiological maturity to control insect, mould and aflatoxin contamination,
- The Kawanda biomass maize dryer dried maize to safe storage moisture content within 4 hours compared to bare ground drying which took 4 days, and reduced insect damage, mould (*Aspergillus*, *Fusarium* and *Penicillium* spp) infection and aflatoxin contamination of maize grains (shelled and unshelled) stored for 6 months, by more than 20%.
- Angoumois grain moth (*Sitotroga cerealella*) was the only insect found to infest maize dried with a biomass dryer while both Angoumois and maize weevil (*Sitophilus zeamais*) highly infested maize dried on bare ground.
- In the laboratory *(in vitro)*, neem kernels were found to inhibit growth of *Aspergillus penicilliodes, A. glaucus, A. fumigatus, A. ochraceous, Penicillium italicum, P. expansum* and *Fusarium verticillioides* but not *A. flavus, A. niger* and *Rhizopus stolonifer*.
- Since growth of *A. flavus* was not inhibited, it implies that neem kernels cannot help those who store maize to control aflatoxins.

Coffee Wilt Disease (CWD)

- Field studies with 270 suspected plant hosts and green house pathogenicity tests using various suspected alternate hosts including banana (Pisang awak) confirmed that *Fusarium xylarioides*, the causal agent of CWD is only pathogenic to *Coffea canephora* (robusta coffee). This indicates that disease transmission and spread does not depend on alternate hosts.
- Green house pathogenicity trials confirmed that spores (*in situ*) from perithecia of *Giberella xylarioides* (the sexual stage of *Fusarium xylarioides*) did incite disease symptoms. However, trapped water runoff (rain-water) from infected coffee plants caused 2.5% seedling mortality when used as inoculum under green house studies. It was therefore concluded that disease transmission from plant to plant could be possible through running rainwater.
- Green house pathogenicity studies confirmed that disease transmission by infected coffee husks is possible and can cause mortality of up 2% under green house studies. This percentage is quite significant in that it can act as a disease focal source of inoculum. Therefore, mulching coffee fields with coffee husks, which is commonly practiced in Uganda, should be discouraged.
- It has also been confirmed that CWD can be transmitted through asymptomatic seedlings collected by farmers from underneath infected field or forest plants which is commonly practiced in Uganda. Recent studies found that > 30% mortality was possible with plants collected from underneath infected field plants while > 10% mortality was possible with seedlings from infested forest coffee seedlings. Although farmers in Uganda sometimes obtain their planting materials from such sites, this should be discouraged.
- Coffee wilt disease development in the field is erratic and does not follow a specific pattern from the inoculation source. Despite all this, the pathogen has persistently not been recovered from aerial traps despite repeated trials indicating that aerial spread is not common.
- Infested soil was confirmed as a source of *Fusarium xylarioides* inoculum causing mortality of up to 2%. Farmers are therefore discouraged from planting coffee on previously infested fields.
- Various insects have been screened for *Fusarium xylarioides* transmission. As of now, none have been found to carry the pathogen, although studies are still going on to screen more insects for possible transmission.
- Morphological and cultural characters were not effective to characterize *Fusarium xylarioides* isolates, although could be used to distinguish them from other species. A more accurate PCR based molecular method was considered to be more efficient in pathogen characterization. Two Research scientists (Drs, Africano Kangire and Georgina Hakiza) were sent for training at Ohio State University in molecular characterization of fungal pathogens and in particular *Fusarium xylarioides* as a technology transfer in biotechnology skills. After both of them had characterized a total of 56 isolates from different parts of Uganda through DNA phenotyping and sequencing, they concurred that there is no genetic variations among Ugandan isolates of *Fusarium xylarioides*. This information is important for breeders, as they develop new resistant varieties since they do not have to deal with various strains.
- It was confirmed through rigorous pathogenicity tests that pathogen infection is exclusively through wounds and especially on roots. Pathogenicity through leaves was impossible while it was not fully systemic through upper parts of the stems. This means that farm activities, which inflict wounds on roots or stems such as hand hoes, and contaminated pruning knives should be discouraged especially in infected fields.
- Clonal coffee cuttings for nurseries from infected plants result into high mortality rates and pathogen isolation was possible. This means that apart from transmitting the pathogen, it is not profitable for nursery operators to use cuttings from such plants as the losses in nursery establishment are quite high.
- Coffee seeds from infected plants resulted into lower germination rates. Although the pathogen did not develop on such plants, it was obvious that its effects

reduce seed germination.
- Recovery of the pathogen (*Fusarium xylarioides*) in coffee debris declined significantly in previously infested fields. The pathogen was not isolated from such fields 14 months after re-planting with new coffee. Additional studies done at the Fusarium Centre at Pennsylvania State University, confirmed that the pathogen couldn't be isolated from mere infested field soil. This may indicate that the pathogen is a weak competitor in soil and therefore field fallowing recommendations are possible after one year.

Assessing the potential of soil-inhabiting *Pseudomonas* for biocontrol of coffee wilt disease: A study to determine the potential of indigenous phlD+ fluorescent pseudomonas for the control of coffee wilt disease has been initiated. To date, protocols initially developed at Ohio State University for the detection and characterization of *Pseudomonas fluorescens* isolates, have been tested at Makerere University and are now available to implement field screening.

Technology Transfer and Training Events:
- **Striga Management Training**: was conducted with 240 farmers in Eastern Uganda.
- **Farmer Field Training Schools**: were conducted with 120 farmers in Kumi and Pallisa districts, focused on scaling-up the dissemination of cowpea and groundnut IPM practices.
- **Tomato Grafting Training**: was conducted in Mpigi district with 34 farmers.
- **Pesticide Safety Application training**: was conducted with 36 pesticide dealers and farmer field schools focusing on the same topic were organized for 450 farmers in three districts in Uganda.
- **Pest and Disease Monitoring training for scotch bonnet peppers**: training was provided for 10 Scotch Bonnet producers.

National Level Impacts

- **Cowpea**: The PA and survey activities repeatedly established that the most likely field crop in Eastern Uganda to be sprayed with chemical pesticides are cowpea. Over 70 percent of farmers growing cowpea apply pesticides with some farmers spraying as often as 8 times per season. The major insect pests are pod sucking bugs (*Riptortus* spp., *Nezara viridula*, *Acanthomia* spp. and *Anoplocnemis* sp.), *Maruca* sp., blister beetle (*Mylabris* spp.) and aphid (*Aphis fabae*). Compared to farmer practices (late planting, broadcast seeding, and 5 spray applications), the IPM CRSP package consisting of early planting, close spacing (45x15cm and 30x10cm) and three sprays (once each at budding, flowering and podding) increased farm income by $72 per hectare. At $59 per hectare per application, eliminating two sprays from the farmers' practices can save them $118 per hectare. Eliminating two sprays also decreases the environmental impacts of cowpea production as each spray contains a mixture of cypermethrin (200g ai/ha) and dimethoate (200g ai/ha). Assuming a 25% adoption rate of this IPM package at the national level, total annual farm income could increase by $ 1.1 million.

- **Sorghum/*Striga* Control**: Sorghum intercropped with *Desmodium uncinatum* could increase farm income by up to $26 per hectare while intercropping sorghum with *Celosia argentea* could increase farm income by $8 per hectare. At the national level, with a 25% rate of adoption of these practices, the *Desmodium uncinatum* intercrop could increase income by $ 0.9 million per year, while the *Celosia argentea* intercrop has the potential to increase income by $ 0.3 million per year.

- **Post-harvest storage of cowpeas and beans:** - The efficacy of using biorational products, solarization, and synthetic insecticides to control bruchid damage (*Acanthoscelides obtectus* and *Callosobruchus* spp.) in stored cowpea an beans was compared. The most effective post-harvest treatments for beans in controlling damage were tobacco dust, Actellic, ash, and solarization. The most effective treatments for controlling damage in stored cowpea were solarization, tephrosia and tobacco. An economic assessment of these same treatments indicated that wood ash, solarization, tephrosia, and tobacco provided economically viable post-harvest protection of cowpeas for up to 3 months. The additional benefits from these controls were realized mainly as a result of higher returns from delayed marketing and/or sowable surplus or lower cost of grain protection. Although the economic analysis generally confirms the results of the biological analysis there were two important differences. First, admixing cowpeas with tobacco powder was viewed favorably from a biological perspective though this option was not found as economically viable. Conversely, treatment with wood ash did not appear to be very efficacious from a biological perspective, but was preferred from an economic context because ash was valued at zero cost.
    - **Post harvest storage bruchid control – Beans**: At the farm level *Tagetes* produced an increase in income of $ 1.00 per 100 kilograms of stored beans and tobacco resulted in an increase in income of $1.61 per 100 kilograms of stored product. With a 25% adoption rate, this farm level income increase has the potential to increase annual income at the national level by $ 1.3 million for Tagetes and $2.2 million for tobacco.
    - **Post harvest storage – Cowpea**: At the

farm level, *Tephrosia* produced an increase in income of $ 3.36 per 100 kilograms of stored cowpea and solarization resulted in an increase in income of $3.18 per 100 kilograms of stored product. At the national level, with a 25% adoption rate, this farm level income increase translates into approximately $ 0.5 million for both of these practices.

- **Bean Fly Control**: Earthing up during weeding can increase farm income by $116 per hectare and if this practice is adopted by 25% of bean farmers, the annual national level increase in income could be $9.3 million.

- **Potato Late blight control**: Potato late blight (*Phytophthora infestans*) is one of the most serious diseases hampering potato production in Uganda. Monitoring disease and spraying when essential (2 sprays) reduced the need for spray applications and was as effective as bi-weekly application of Dithane M45. Integrating host resistance, disease monitoring and then spraying, reduced pesticide application by >50% without causing yield loss. Using monitoring to determine when to spray for late blight control on potatoes can increase farm income by $516 per hectare, and annual national income by $7.8 million, with a 25% adoption rate of this practice.

- **Groundnuts**: – The participatory assessment, the initial baseline survey, and farmer field monitoring activities all identified groundnut rosette virus (GRV) as the primary constraint on groundnut production. An IPM package consisting of early planting, use of a rosette resistant variety (Igola-1) disseminated and popularized by the IPM CRSP, intermediate plant density (45 x 15 cm2) and a reduced spray program of 2-3 times (compared to the farmer practice of spraying 5-6 times) had the lowest incidence of GRV and cercospora leaf-spot (*Cercospora arachidicola*). Igola-1 with low density early planting resulted in an increase in net farm income of $125 per hectare whereas medium density early planting of Etesot produced an increase of $134 per hectare. At a 25% level of adoption, annual national level income could increase by $3.2 million with this Igola-1 system, and $3.5 with this Etesot production system.

- **Cotesia – stem borer control**: *Cotesia flavipes* Cameron, a braconid parasitoid of *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae), was first released during the 1st rainy season of 1998 in Iganga and Kumi Districts in Eastern Uganda. Rearing of stem borers collected from maize sites in Iganga and maize/sorghum sites in Kumi during the 2nd rainy season 1999 and 1st rainy season 2000, found parasitism levels of *C. flavipes* on *C. partellus* to be 10.6% and 30.8% in Iganga, and 32.7% and 24.1% in Kumi, for the two seasons. This demonstrates establishment of *C. flavipes* in both districts. Dispersal of *C. flavipes* to sub-counties neighboring release sites has been demonstrated by parasitism levels equal to that observed in the sub-counties where the parasitoid was initially released. With a 41% to 53% estimated maize yield increase from stem borer control by *Cotesia flavipes*, and conservatively assuming that this intervention will only benefit 5% of the maize production areas, annual national level income could increase from between $4.0 million to $5.2 million from this biological control program.

Publications

Erbaugh, J. Mark, J. Donnermeyer, M. Amujal, S. Kyamanywa, 2003. The Role of Women in Pest Management Decision Making in Eastern Uganda. Journal of International Agricultural and Extension Education, 10 (3), 71-81.

Pratt, R., Gordon, S., Lipps, P., Asea, G., Bigirwa, G., and Pixley, K. 2003. Use of IPM in the control of multiple diseases in maize: strategies for selection of host resistance. African Crop Science Journal 11:189-198

Kaaya, N. A. 2004. DithaneM-45 residues in tomatoes on Ugandan markets may be above safe levels. African Journal of Food, Agriculture, Nutrition and Development, Vol. 4, No.1. www.ajfand.net

Kaaya, N. A. 2003. Kampala's consuming poisoned food! The Economic News. November 5 -12, 2003. The Economic News Publications Company Ltd. P.O. Box 1237, Kampala. pp 1 – 2.

Bigirwa, G, Imanywoha, J., Alupo, J., Ebellu, M. and Kyetere, D.T. 2003. Tolerance and resistance of maize hybrids to maize streak virus in Uganda. Uganda Journal of Agricultural Sciences 8: 80-84.

Nabirye J., Nampala, P., Ogenga-Latigo, M.W., Kyamanywa, S., Wilson, H., Odeke, V., Iceduna, C and Adipala, E (2003) Farmer-participatory Evaluation of Cowpea integrated pest management (IPM) technologies in Eastern Uganda. Published in the Journal of Crop Protection. Pages 31-38.

Nabirye J., Nampala, P., Kyamanywa, S., Ogenga-Latigo, M.W., Wilson, H., and Adipala, E (2003). Determination of damage-yield loss relationships and economic injury levels of flower thrips on cowpea in eastern Uganda. Published in the Journal of Crop Protection. Pages 911-915.

Opolot, H.N., Kyamanywa, S., Agona, A., Mbata, G.N., and E. Adipala (2004). Validation of action thresholds for flower thrips on cowpea in Uganda. In press.

Opolot, H.N., Kyamanywa, S., Agona, A., Mbata, G.N., and E. Adipala (2004). Integrated field management of cowpea pests using selected synthetic and botanical pesticides. In Press

Olupot, J. R., Osiru, D. S. O., Oryokot, J and Gebrekidan, B. 2003. The effectiveness of Celosia argentia (Striga "chaser") to control Striga on Sorghum in Uganda. Published in the Journal of Crop Protection. Pages 463-468.

Munyuli, M.B.T., Luther, G.C. and Kyamanywa, S. (2004). Effects of cowpea cropping systems and insecticide applications on abundance and diversity of indigenous arthropod predators and parasitoids in Uganda and Democratic Republic of the Congo. In Press.

Munyuli, M.B.T., Luther, G.C. and Kyamanywa, S. (2004). Capability of *Forficula auricularia Linnaeus* (Dermaptera: Forficulidae) to prey on *Aphis craccivora* Koch (Homoptera: Aphididae) in eastern and central Africa. In press.

Munyuli, M.B.T., Luther, G.C. and Kyamanywa, S. Kyamanywa (2004). Capability of *Cheilomenes lunata Fabricius* (Coleoptera: Coccinellidae) to prey on *Aphis craccivora* Koch (Homoptera: Aphididae), in eastern and central Africa. In Press

Adipala, E. and Okori, P. 2004. Designing and managing Research: In: The Green Book. B.K. et al. (Eds.).

Asio, M.T., Adipala, E. and Osiru, D.S.O. 2003. Farmer evaluation of an advanced cowpea line for agronomic performance in eastern Uganda. MUARIK Bulletin 6:15-20.

Namanda, S., Adipala, E., Olanya, M. and El-Bedewy, R. 2004.On-farm evaluation of fungicide spray options to control potato late blight in South-western Uganda. MUARIK Bulletin 7 (in press).

Ivey M.L., Miller S.A., Hakiza G.J., Geiser D.M. (2003). Characterization of the Coffee Wilt pathogen in Uganda. Phytopathology 93: S50.

Geiser D.M., Ivey M.L., Hakiza G.J., Juba J.H., Miller, S.A. (2004). *Gibberella xylarioides* (anamorph: *Fusarium xylarioides*) a causative agent of coffee wilt in Africa is a previously unrecognized member of the *G. fujikuroi* species complex. In press: Mycologia.

Kangire, A., Olal, S. and Kabole, C. (2003). Evaluation of potential sources of inoculum for the coffee wilt epidemics in Uganda. Uganda Journal of Agricultural Sciences, 8: 37-40 p.

Hakiza, J.J., A.B. Mutooro, K. Ahwoi and M.C. Akemo. (In press). Horticultural industry in Uganda: from potential to potential. African Crop Science Conference Proceedings, Vol. 6:

Hakiza, J.J., W. Odogola, J. Mugisha, A.R. Semana, J. Nalukwago, J. Okoth and E. Ekwamu. 2004. Challenges and prospects of disseminating technologies through farmer field schools: Lesson learnt based on experience from Uganda. Uganda Journal of Agricultural Sciences 9(11): 163-175.

Kakuhenzire, R., J.J. Hakiza, E. Adipala, W. Wagoire and Berga Lemaga. 2004. Yield stability and acceptability of two new Solanum potato varieties in Uganda. Uganda Journal of Agricultural Sciences 9(11): 718-722.

Kankwatsa, P., J.J. Hakiza, M. Olanya, H.M. Kidanemariam, and E. Adipala, 2003. Efficacy of different fungicide spray schedules for control of potato late blight in Southwestern Uganda. Crop Protection 22:545-552.

Namanda, S., O.M. Olanya, E. Adipala, J.J. Hakiza, R. El-Bedewy, A.S. Baghsari and P. Ewell. (In press). Fungicide application and host resistance for potato late blight management: benefits assessment from on-farm studies in S.W. Uganda. Crop Protection

Presentations

Erbaugh, J.M., (2004). IPM Lessons from Africa: What worked, what didn't, what will continue, and what is needed? Presented at the Workshop on Globalizing IPM through Participatory Research: Lessons from the IPM CRSP. August 5-6, Washington, D.C.

Erbaugh, J., Amujal, M., Kyamanywa, S., and Adipala, E. (2003). Women's Knowledge and Role in Crop Pest Management Decision Making in Easter Uganda. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Asea, G., Lipps, P.E., Gordon, S., Adipala, E. and Prat, R.C. Development of inoculation procedures for evaluation of partial resistance to *Cercospora zeae-maydis* in young maize plants. Presented at the 6th African Crop Science Conference, 12-17 October, Nairobi, Kenya,

Pratt, R. Pyramiding genes for resistance to multiple diseases in maize. Presented at the 6th African Crop Science Conference, 12-17 October, Nairobi, Kenya,

Kaaya, A. N. 2003. Aflatoxin status in Uganda. Paper

presented during the UNBS Workshop on National Food Control System and Strengthening of The National Codex Committee. 29 – 31, October, 2003. Grand Imperial Hotel, Kampala.

Kaaya, N. A., H. Warren, W. Kyamuhangire, S. Kyamanywa, A. Agona and G. Bigirwa. 2004. Effect of delayed harvest on quality of maize in Mayuge district of Uganda. Faculty of Agriculture Annual Graduate Workshop, August 28, 2004. CAEC, Makerere University.

Sseruwu, G. Bigirwa, G., Adipala, E. and Kaaya, A.N. 2003. Fungal microflora causing maize ear rots in Uganda. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Akemo, M. C, Kyamanywa, S., Adipala, E., Wilson, H., And Erbaugh, M. 2003 Studies on some integrated pest management systems for tomato: a case study from Uganda. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Kyamanywa, R., Kawooya, H.F and Kafeero, C. 2003. Damage Yield relationships due to flower thrips (*Megalurothrips sjostedti*) on groundnuts (*Archis hypogea L*). Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Kagezi, E. L., Kyamanywa, S., Akemo, M.C and Hammond, R. B. 2003. Yield loss assessments due to Thrips tabaci (Thysaonptera:Thripidae) management on French beans (*Phaseolus vulgaris* L.). Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Olupot, J. R., Oryokot, J., Osiru, D.S.O., Gebrekidan, B and Warren, H. 2003. The potential of using silver leaf desmodium (*Desmodium uncinatum*) for the control of Striga on sorghum in Uganda. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Asea, G., Lipps, P.E., Gordon, S., Adipala, E and Pratt, R.C. 2003. Development of inoculation procedures for evaluation of partial resistance to *Cercospora zeae-maydis* in young maize plants. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Sseruwu, G., Bigirwa, G. and Adipala, E. 2003. reaction of Ugandan commercial and elite maize materials to two most common ear rot causing pathogens; *Fusarium moniliforme* and *Stenocarpella maydis*. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Wasukira, A., Hakiza, G. J., Adipala, E. and Kyetere, D. T. 2003. Identification of infection avenues of *Fusarium xylariodes* in coffee tissues. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Munyuli, T.M.B., Kyamanywa, S. and Luther, G.C. 2003. Effects of seasons and ecological zones, on the distribution, abundance and diversity of native predator and parasitoid arthropods of cowpea and groundnut pests. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Agona, J.A and Muyinza, H. 2003. An evaluation of synergism between crude botanical extracts against *Acanthoscelides obtectus Say* (Coleoptera:Bruchidae) on stored beans. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Lubadde, G., Kangire, A., Adipala, E. 2003. Significance of infected planting materials and alternate hosts of *Fusarium xylarioides* in transmission of coffee wilt disease. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Hakiza, G.J., Kyetere, D. T., Erbaugh, M., Warren, H., Olal, S. (2004). Seed transmission of *Fusarium xylarioides* in *Coffea canephora* in Uganda. Proceedings of the International Conference on Integrated Agricultural Research for Development. Botanical Beach Hotel Entebbe, September 1 – 3 2004.

Hakiza, G.J., Kyetere, D.T., Olal, S. (2004). Mode of penetration and symptom expression in robusta coffee seedlings inoculated with *Gibberella xylarioides*, the cause of coffee wilt disease in Uganda. Paper prepared for presentation at the 20th International Conference on Coffee Science, ASIC 2004, Bangalore, India, October 11 – 15, 2004.

Kangire, A., Kyetere, D., Hakiza G., Otim-Nape, G.W and Adipala, E. 2003. The occurrence and impact of coffee wilt disease in Uganda. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Hakiza, J., Mutooro, A., Ahwoi, K and Akemo, M.C. (2003). Horticultural industry in Uganda: from potential to potential. Paper presented during the Sixth African Crop Science Conference, 12-17 October, Nairobi, Kenya.

Graduate Student Theses

Mrs. Magdalene Amujal
MSc. Thesis Title (completed)
Assessing the Influence of Farmer Field Schools on Adoption of Ipm Technologies by Cowpea Farmers in

Eastern Uganda

Mr. G. Lubadde
MSc. Thesis Title (submitted)
Significance of infected planting materials and alternative hosts of *Fusarium Xylarioides* Steyaert in transmission of coffee wilt Disease (2004).

Mr. T. M. B. Munyuli
MSc. Thesis Title (completed)
Species diversity, abundance and impact of indigenous natural enemy of cowpea pests in eastern Uganda and Democratic Republic of Congo (2003).

Mr. G. Sseruwu
MSc. Thesis Title (completed)
Fungal Microflora causing maize ear rots in Uganda (2003).

Mr. A. Wasukira
MSc. Thesis Title (submitted)
Assessment of the infection avenues of *Fusarium xylarioides* into coffee and histopathology of the inoculated coffee tissues. (2004).
Mr. E. L. Kagezi
MSc. Thesis Title (completed)
Damage-yield relationships of thrips and the influence of various management practices on thrips and other major pests of tomatoes in central Uganda (2004).

Mr. H. N. Opolot
MSc. Thesis Title (completed)
Integrated field management of cowpea pests using selected sysnthetic and botanical pesticides (March 2004).

Overview of the Central America Site in Guatemala and Honduras

Stephen C. Weller, Site Chair (Purdue University), Luis Calderón, Site Coordinator (ICADA, Guatemala)

The Collaborative Program

The IPM CRSP Central American Site had a productive program agenda in Year eleven. The site operates through an active site committee structure, with Guatemala as the prime site for Central America. Ing. Luis Calderón (ICADA) is the regional site coordinator for Central America. The Regional Site Committee is comprised of Luis Calderón and Guillermo Sánchez (ICADA), Margarita Palmieri (UVG), Danilo Dardón, (ICTA), Jorge Mario Santos (MAGA), Luis Caniz (APHIS-IS), Linda Asturias (ESTUDIO 1360), and Maria Mercedes Doyle (ZAMORANO) and Dr. Dale Krigsvold (FHIA). The U.S. researchers that collaborate with the regional site committee and provide research support, technical support, and program coordination include: Drs. Stephen C. Weller, U.S. Site Chair; C. Richard Edwards and Ray Martyn (Purdue University), Sarah Hamilton (Adjunct Professor-Virginia Tech), David Orden, (Virginia Tech), Judy Brown (University of Arizona), and Michael Deom (University of Georgia). The overall Central American site activities in Year eleven were funded through USAID IPM CRSP under subcontract with Virginia Tech.

Preliminary research agendas and budgets for the Central America Site are established during the annual Technical Committee Meetings. These broad research agendas are then presented to the Site Committee for review, discussion, and prioritization of specific research activities for the year following the participatory format of the IPM CRSP. The Site Committee meets on a regular basis to discuss research progress and make consensus decisions on any revisions. Each collaborator and/or collaborating institution has the opportunity throughout the year to request revisions in previously approved research agendas and budgets. Such revisions require Site Committee consensus.

The Honduran Foundation for Agricultural Research (FHIA) and ZAMORANO were the principal regional collaborating institutions outside Guatemala in Year eleven. Substantive discussions were conducted with the Honduran and El Salvadoran Ministries of Agriculture to lay groundwork for future collaboration with IPM CRSP and site expansion if the project is renewed after year eleven.

In Guatemala, APHIS, MAGA, and AGEXPRONT continued to provide strong collaborations in the development of IPM/Integrated Crop Management (ICM) strategies for reducing pesticide use, increasing product quality, and improving the performances for achieving safer food supplies in the NTAE sector.

APHIS-IS and MAGA (Ministry of Agriculture, Guatemala) continued to provide collaborative leadership in the development and institutionalization of preinspection programs in Guatemala. GOG grants to IPM CRSP researchers at Universidad del Valle, ICADA and AGEXPRONT provided funds for community level research transfer activities and training, including field demonstrations. ICTA and UVG have continued to collaborate in testing and revising IPM CRSP production strategies for improved pest management in snow peas (leaf miner), tomatoes (white fly), broccoli (*Plutella xylostella*), and papaya (papaya ringspot potyvirus). ESTUDIO 1360, in collaboration with Dr. Sarah Hamilton contributed substantively to research activities that evaluated the socioeconomic impacts of NTAE production at the community and household levels.

IPM Constraints Addressed

Institutional policies

Science-based production and preinspection policies that lead to reduced pesticide usage, decreased product rejections at U.S. ports-of-entry and increased market opportunity continued to be the major focus to address some key institutional constraints in Central America. In Guatemala, MAGA endorsed these efforts in Year eleven through programs and national policies that encourage substantive adoption at the national level. Private sector involvement has centered on the development of regional consolidation and distribution centers, the first such facility opened in San Cristobal Totonicapan under the direction of the Asociación of Fruticultores Agrupados (FRUTAGRU); and on the development of pre-inspection manuals for NTAE crops, specifically snow peas, tomatoes and broccoli. GOG initiatives to revise policies commensurate with the demands of a more competitive marketplace in the NTAE sector are now receiving serious consideration.

The need for continuity and enforcement of public and private sector policies such as credit availability at the producer level continues to influence NTAE development in Central America, including the implementation and institutionalization of performance-proven IPM/ICM production practices and certified pre-inspection programs. In Guatemala, the GOG continued a proactive role. AGEXPRONT and ICTA, in collaboration with the IPM CRSP, have continued to play a central role in developing more proactive field level training in production and post-harvest policies that serve to enhance performance in the NTAE sector.

Technology Transfer

The IPM CRSP continued transferring specific production practices literature on biorational IPM/ICM technology to NTAE producers and field technicians in Year eleven which helps many small independent NTAE producers reduce reliance on chemical control practices and use of unregistered pesticides for insect and disease control. This training allows IPM CRSP approved pest management information to be transferred through grower workshops, technician seminars, and field demonstrations to the actual practitioners. These technology transfer and field demonstration activities will be enhanced as the GOG accelerates program initiatives in preinspection and grower certification. ICTA, AGEXPRONT, FRUTAGRU and PIPAA (Integrated Program for Protection of Environment and Agriculture, GOG) played important roles in these training and technology transfers. ICADA prepared a pre-inspection manual for snow pea producers and this is now available for grower use.

Research Capacity

A "critical mass" of trained field technicians has been assembled who are capable of addressing pest management problems using applied science-based protocols and approved IPM/ICM practices developed and transferred by the IPM CRSP. AGEXPRONT and ICTA, in collaboration with IPM CRSP researchers, have played an important role in achieving these results.

The IPM CRSP socio-economic research activities, under the leadership of Dr. Sarah Hamilton and her collaborators at ESTUDIO 1360, have continued their quantitative assessments of socio-economic benefits in NTAE producer households. This research has provided excellent documentation needed for strengthening the policy and program commitments from the GOG, AGEXPRONT, and other private sector collaborators to small farm households. Over two-thirds of the NTAE households report that they have improved quality of life since 1980, including housing, health care, education, and nutrition. NTAE earnings enabled 39 of 45 individuals surveyed to buy land, which resulted in a modest decrease in the land ownership concentration over the last 20 years. These findings clearly helped the GOG make positive determinations in providing funds to support the development of the first grower-based supply consolidation and preinspection center in the NTAE sector (FRUTAGRU center, November 2003). The IPM CRSP has and will continue to play an instrumental role in training and technology transfer as additional distribution and preinspection centers are developed.
Research collaborations between the U of Georgia, AGEXPRONT, and APHIS have helped resolve the ringspot potyvirus problem in papaya in Year Nine through Year eleven. This coupled with the IPM CRSP/APHIS supporting documentation to achieve clearance for papaya into U.S. ports-of-entry provides the basis for significant NTAE trade expansion in the future once commercially acceptable papaya cultivars are developed.

Institution Building

The Government of Guatemala, through MAGA and ICTA, continued to support the IPM CRSP's overall objectives for strengthening scientific capacity and market-focused planning in the NTAE sector. These institutional linkages continue to be among the most important factors in moving the IPM CRSP research and development agenda forward in Central America. The continued GOG commitment provides clear evidence of the IPM CRSP's role in institution building in Central America. Institutional collaborations with FAS, APHIS, FAO have been critically important in the past in helping develop additional program funding and capacity for the IPM CRSP. USAID Mission's commitment to microenterprise financing in Guatemala is a cornerstone for the institutionalization of greater access to credit among small NTAE producers which will remove a major constraint to NTAE expansion and the implementation of biorational production programs.

During Year nine and ten institutional relationships and research capacity were strengthened in Honduras. Discussions between the IPM CRSP and the Ministry of Agriculture, FHIA and Zamorano resulted in the finalization of an MOU between the IPM CRSP and the GOH, and the award of a $100,000 USD research grant (FAS/GOH) to strengthen research collaborations in resolving the disease problems associated with virus pathogens in NTAE crops. This research lead to an IPM CRSP biotechnology grant for Years ten and eleven (University Arizona, Zamorano, FHIA, Purdue University and University of Georgia) to continue and expand this research into the search for resistance genes to gemnivirus in Solanaceous crops.

The IPM CRSP in Central America continues to place a high priority on strengthening the institutional capacity of collaborators and collaborating institutions. IPM CRSP scientists in the United States have given high priority to strengthening institutional capacity in research, technology transfer, and program implementation. In Year 11, visits to Honduras included discussions regarding research priorities and future collaborations between the IPM CRSP and the Ministry of Agriculture.

Student Training

Dafne Morales, a native Guatemalan, completed short-term research training at Purdue University in the 2004 summer term. Ms. Morales worked under Stephen Weller

in the Horticulture and Landscape Architecture Department. Her research and training provided hands-on laboratory and field in integrated pest management. Ms. Morales will complete her Bachelor's degree at the Universidad del Valle in 2005 and has an interest in returning to the U.S. for graduate studies.

Jonathan Samuel Nolasco, Universidad de San Carlos de Guatemala worked with ICTA on research involving use of faba bean as an integrated crop management strategy to control thrips in snow pea. The research was conducted in Xeabaj, Santa Apolonia and Chimaltenango and was conducted as part of senior thesis.

M. Espinoza, I. Donis and F. Mejia are students at Universidad del Valle who work with Dr. Margarita Palmieri on the transformation of Papaya. The research involved training in tissue culture and genetic engineering techniques and is part of their undergraduate training.

Networking

Collaborations with APHIS-IS in the development and testing of preinspection programs have helped to further expand the IPM CRSP networking activities in Year eleven. This collaboration was strengthened through activities associated with USDA's formal approval of Guatemalan papaya into U.S. markets, and will allow expanded program development of the Petén Region for papaya production.

Private sector grower-shippers and shippers of NTAE crops continue to participate in the IPM CRSP led initiative as "technology transfers agents". This activity has allowed our technology transfer program to reach over 13,000 small farm producers, field technicians, and community leaders throughout Guatemala and Central America in year ten and eleven. This networking activity will continue to be important as the GOG implements regional supply consolidation/preinspection centers, and institutionalizes preinspection protocols and policies.

Networking activities at the district and community levels continued to expand in Year eleven as additional households in the Chimaltenango District were surveyed in the socioeconomic assessments. Overall the IPM CRSP has networked with over forty communities throughout Guatemala. These collaborations serve as the basis for continuing research and outreach activities. In addition, gender and socioeconomic impact studies were continued at the community level in Guatemala. This networking activity has greatly enhanced the socioeconomic knowledge base of the IPM CRSP, and has generated important gender, household, and NTAE impact conclusions for publication.

Training seminars for NGO's, independent private sector crop management technicians, and PIPAA personnel focused on the transfer of IPM CRSP pest management strategies and preinspection performance protocols. All training seminars were supplemented with published research materials and user manuals developed by ICTA in collaboration with AGEXPRONT and IPM CRSP researchers.

Institutional networking activities continued in Year eleven as pre-inspection policies in snow pea were institutionalized for implementation by the GOG. ICTA, ICADA, MAGA, APHIS, and AGEXPRONT continued to play important collaborative roles in preinspection research, development, and implementation. In addition, PIPAA, a joint MAGA/private sector entity, was commissioned by the GOG to handle preinspection program implementation, compliance, and enforcement in Guatemala's NTAE sector with assistance in manual preparation by Luis Calderón, IPM CRSP Central American Site Coordinator. This important networking activity required a substantive commitment from the IPM CRSP in training and knowledge transfers and resulted in the finalization of the pre-inspection manual for snow peas.

The IPM CRSP continued to strengthen networking activities in Honduras in Year eleven. Research continued to provide more information regarding identification and management factors responsible for limiting melon production in Southern Honduras. This continued research is related to the previous research proposal funded in year nine to address the issue of plant virus pathogens that cause serious damage to the melon crop in Honduras. Melons, particularly cantaloupe during the period January through April, comprise Honduras' most important NTAE crop. However, plant virus diseases currently threaten nearly 11,000 acres of melon for export to the United States valued at over $24 million USD. The IPM CRSP, under the leadership of Drs. Ray Martyn at Purdue University, Dr. Dale Krigsvold of FHIA and Maria Mercedes Doyle at Zamorano, and Dr. Judy Brown at University of Arizona are conducting research to study these problems. Also, a biotechnology grant from IPM CRSP supports the research of this group to identify geminiviruses in tomatoes and to investigate how genetic engineering for resistance might alleviate this problem.

In August, IPM CRSP representatives (S.C. Weller, L. Calderón and G. Sánchez) visited Honduras and El Salvador to discuss research needs in IPM and the potential for future collaborations between the IPM CRSP and Honduras. Useful discussions were held with representatives of the Ministry of Agriculture and site visits were made to view research farms and grower locations. There are many common interests for future

site expansion into Honduras and a great interest in NTAE crop expansion based on sound IPM production practices.

The IPM CRSP continued to strengthen networking activities with the University of Georgia, The National Science and Technology Council in Guatemala, and The National Papaya Growers Association in addressing the ring spot potyvirus in papaya. These networking activities were expanded and strengthened in Years ten and eleven.

Research Accomplishments

- Socio-economic impact research was designed to provide a follow-up to baseline and interim household socio-economic surveys conducted in 1998 and 2001. These surveys addressed IPM practice and adoption constraints in the context of social and economic impacts of adopting IPM CRSP target crops (snow peas and broccoli) in two communities of small-scale Maya farmers and medium-scale NTAE growers in Chimaltenango. For the final follow-up research, both quantitative and qualitative methods were used to capture the economic and social dynamics of IPM adoption, including credit and labor constraints, access to IPM technology, NTAE and other market factors, and perceived costs and benefits of current pesticide regimes and IPM practices. The changing role of NTAE production in family economies was also investigated, as relative importance of NTAE crops among other sources of farm family livelihoods and the perceptions of NTAE economic returns over time are important hypothesized correlates of IPM adoption. Information was collected on family and hired labor in agricultural production and commercialization, on-farm and off-farm labor generated by NTAEs, and intra-household economic decision processes (including roles of women in IPM labor and decision processes and women's attitudes about pesticide use). As data collection is in progress, no results are yet available. Quantitative data collection has been completed in one of two communities from the baseline surveys (Xeabaj); data collection is on-going in the second community. A probabilistic random sample of 68 households was interviewed in Xeabaj. Both male and female household heads were interviewed, separately, from each household. This method of sampling allows analysis across the full range of variation in farm size, NTAE production variables, and IPM adoption variables. Inclusion of women from all households allows analysis of gender and IPM adoption. This sampling method has proved an important component of data quality in earlier surveys and facilitates comparison among baseline and follow-up surveys. One of the goals of the research was to facilitate comparison between (a) farmers involved in IPM CRSP research and extension activities and (b) other farmers with similar production profiles who are not involved in these activities. To this end, a representative sub-sample of farmers involved in IPM CRSP activities who were not included in the probability sample were added to the original sample. Qualitative data collection is on-going. Qualitative data collection from farmers affiliated with various production groups—some of which are involved with the IPM CRSP—is being carried out in both communities. A detailed accounting of IPM knowledge, attitudes, and practice is being collected. Qualitative research also addresses the history of farmers' knowledge acquisition and IPM adoption, as well as farmers' cost-benefit analyses and other logics that contribute to adoption or non-adoption of IPM practices known to farmers.

- The Year eleven work at UVG in biotechnology involved tissue culture laboratory and greenhouse studies involving transformation of papaya for resistance to papaya ringspot potyvirus. The tissue culture transformation was done using a kanamycin (KAN) gene or a hygromycin (HYG) gene. The objective was to use selectable markers (KAN or HYG) plus the PRV-p coat protein (CP) gene to develop a transformation technique to obtain papaya plants and then to test them for presence of the CP gene and its level of expression. Experiments investigated transformation of local and Hawaiian papayas with these two vectors possessing the PRV-p coat protein gene. Experiments with the HYG construct resulted in a greater number of plantlets than the KAN containing construct. Initially all plantlets were recalcitrant to rooting but this was overcome by adjusting the dose of hormones in the rooting medium.

  Greenhouse work has begun with transformed papaya plants to test for the presence of the CP gene. These plants will be inoculated with the virus to test for resistance level.

- ICTA's research to develop non-chemical alternatives to reduce populations of thrips in snow pea and was carried out in Aldea Xeabaj, Santa Apolonia, Chimaltenango A randomized block design with 6 treatments and 4 replicates was used. Each treatment consisted of 4 different densities of faba bean (0, 2, 4, 8 and 12 plants per posture) and 2 checks (absolute and chemical). Data was taken on the following: Number of thrips in meristems and flowers, pods damaged by thrips, yield and specie of thrips that were present. There was no statistical difference among treatments, showing that faba

planted within the crop did not function as a trap crop to control thrips. Additional studies are suggested to further study this technique. Even though this technique shows limited potential for thrips control, some snow pea producers are including faba bean in their integrated crop management plans to control leaf miner and as a trap/live barrier crop to control thrips, by sowing it around the crop.

- To promote and transfer the IPM technology, ICADA researchers established plots in areas of high production of snow pea, broccoli and tomato (white fly). All plots were linked with training and transference activities for participating farmers, producers, students and exporters. In general, the technology generated by the IPM CRSP over 10 years was applied. The goal was to demonstrate that by correctly integrating all the components of plot management, growers will have improved production quality, higher yields, reduced production costs, and observe a reduction of negative effects to the environment and health of producers and consumers.

  The knowledge participants acquired in the training activities, allowed them to understand that agricultural practices must be identified and carried out under a systems approach, which integrates all components, to obtain a better yields and environmental management. The most important components of this activity were the training of participants, the application of the research generated techniques in production, and most of all, technology transfer and adoption by many producers. Training activities were provided to farmers, students and technicians within the public sector so that they could transfer their knowledge to other farmers and communities. A total of 1737 people were trained; 72% of them were farmers, 9% technicians from various companies and 19% students of agricultural schools and universities.

- The transfer of production technology focused in snow and sweet peas and broccoli; which are crops of higher importance in the Guatemalan highland, was carried out in Sacatepéquez, Chimaltenango, Sololá, Quetzaltenango and Quiché by ICADA with the assistance of trained technicians. The purpose of this project was to transfer integrated crop management technologies to exporters, technicians, community leaders and farmers through five training modules, which were the following: fertilization, pest monitoring, control of pests, management of pesticides and soil conservation.

  Integrated crop management plots were sown in strategic areas where training activities were held. Participants included 3,500 farmers, divided into 32 groups; with five training sessions per group. All participants received a certificate of participation after attending each of the training modules.

  Three of the 32 trained groups received a certificate from the European Union indicating they met the EUREGAP production and handling rules. These three groups sold their product to a European company (SIESA). Seven additional groups are now being trained in these production practices and when finished with the program will also receive the EUREGAP certificate.

- Seven technical publications, which included printed and digital production material of IPM CRSP research findings, were prepared during 2003-04 to further accelerate the distribution and transfer of IPM CRSP research generated techniques for NTAE crops. The centerpiece of these publications was the snow pea pre-inspection manual which was designed, written and published, and became an example of the application of the IPM CRSP research results. Other publications included a tomato, bulletin and digital material describing how to correctly manage tomato plantations to reduce the use of chemicals. Through these materials the recipients received a systematic concept of crop management.

  Vegetable grafting information related to grafting of melons and solanaceous crops as possible organic alternatives more compatible with the environment than high chemical use to combat pest problems was distributed through digital material and bulletins. Through the participation of university students and the agricultural research sector, many of the clientele were motivated to analyze potential applications that this grafting technology that might offer other organic approaches to pest management. All the activities included distribution of printed materials and training of farmers, technicians, exporters, students and researchers in potential production regions.

- ICTA's research on the development of biofumigation for soil preparation free of chemical pesticides as an alternative to methyl bromide fumigation has met with high acceptance and impact in the Guatemalan agriculture. ICTA, IPM CRSP and the University of Almeria have been the pioneers in Guatemala of this technique which is free of chemical pesticide application to the soil used to produce vegetables that will enter local, regional and export markets. This research was conducted to complement and reconfirm previous IPM research showing the potential of biofumigation methods and to provide useful soil fumigation techniques to farmers. The biofumigant technique has filled the

void in pest control that will occur with the elimination of methyl bromide which negatively impacts the ozone layer and will soon be banned from agriculture uses.

- ICTA researchers' development of epidemic bioclimatic models for pests in snow pea and broccoli has shown that they are useful and accurate in predicting pest outbreaks. This will allow targeted applications of pest control tactics rather than programmed application that are made in anticipation of pest problems and should result in reduced pesticide applications during the growing season. This research has led to development of mathematic models useful in validating the results of our previous research. Two experiments were established as a component of the IPM, one in each crop. Information now being generated for development of new models to be compared with the existing models. The results are expected the middle September 2004. This research has impacted positively on the development of new technologies that will eventually be applied in the IPM programs for NTAE crops. The use of the predictive model techniques is a great achievement for agriculture in Guatemala.

- Research carried out by FHIA scientists sought to gain insight into problems farmers face when growing mono-culture melon for more than 20 years. These practices depend heavily on the use of methyl bromide and transplants in the low-organic matter soils of the xeric southern coast of Honduras. These practices predispose melon plants (mostly honeydew and cantaloupe) to vine decline prior to harvest when climatic conditions (relatively low temperatures and high RH) are unfavorable to plant growth, and can result in up to 50% yield loss.

  The diagnoses of vine decline under these conditions indicates that a poorly-developed deep root system (lack of a tap root with laterals) and pre-disposition to normally weakly pathogenic fungi are the main causes of vine decline; the plant does not have a strong enough or well enough distributed root system to support the heavy fruit set of a hybrid melon variety, even when sufficient irrigation water is applied.

  An integrated approach leading to better-developed, more natural root systems and an improved, more natural soil micro-biological complex is being tested over several annual production seasons in an effort to provide a production package to the Honduran melon producers that is sustainable and does not depend upon chemical pesticides. Integrated treatments of green manures, soil solarization, larger transplant production cells that allow tap root development, direct planting, and root innoculation with beneficial fungi (mycorrhizal *Glomus intraradix* and antagonistic *Trichoderma lignorum*) are being tested.

  In the absence of the conditions necessary for vine collapse it has not been possible to see clear differences between treatments and controls. Nevertheless, it was clear that larger transplant cell size provided a much more vigorous root system, that the mycorrhizal fungus association had a beneficial effect on the plant growth and yield, and that all the treatments evaluated offer clean cropping alternatives for melon production in southern Honduras at equivalent or less cost to current practices of small transplants and methyl bromide sterilization of soils. Because this work is being done in close collaboration with the major melon growers of the region, adaptation of the cleaner cultural practices will be integrated quickly into the total production framework of both large and small growers.

- Infectious clones and characterization of three whitefly-transmitted geminiviruses (Genus: *Begomovirus*), and stacked resistance to a begomovirus and tobamovirus of tomato is being conducted through collaborations between The University of Arizona (Judith Brown), Zamorano (M.M. Doyle; FHIA (D. Krigsvold; J. Melgar; and M. Rivera); University of Georgia (M. Deom) and Purdue University (R. Martyn and S. Weller). Three newly described tomato-infecting begomoviruses from Honduras were PCR-amplified, cloned, and the sequence was determined for the DNA-A and DNA-B chromosomes of each. Two of the viruses occurred in a mixed infection in tomato. The three viruses have distinct genotypes (species) and represent two different phylogenetic clades of New World begomoviruses.

  Infectious clones for the viruses are under construction to enable their use as the source of target sequences for virus-derived resistance, and as a source of viral inoculum required to screen germplasm and/or trangenic plants for disease resistance. Together with these three begomoviruses of tomato, several other phylogenetically diverse candidate begomoviruses will be included in the resistance project, including *Pepper golden mosaic virus* (PepGMV), Chino del tomate (Brown et al., 1998) for which infectious clones have been constructed (Year 9-10), Implementing diverse viral genotypes in disease resistance programs will increase the likelihood that cultivars, which are developed through plant breeding and/or using transgenic technologies, will perform well against a wide spectrum of viral genotypes.

In collaboration with The University of Arizona (JK Brown) and the University of Georgia (Mike Deom), efforts are underway to develop stacked resistance in tomato to PepGMV (and diverse begomoviruses) and the tobamovirus, Tomato mosaic virus. Diseases in tomato caused by both of these viruses in Honduras were found to be highly prevalent and widespread during a three-year virus survey, and thus the latter viruses were selected as prototypes for targeting in the disease resistance project.

Virus-derived resistance was considered the most expedient and directed approach for the development of a resistant tomato variety for Honduras (and Guatemala). Constructs for the PepGMV C1 ORF (replication associated protein) and BV1 ORF (nuclear shuttle protein) were made using an inverted repeat strategy to induce post-transcriptional gene silencing of viral mRNA upon entry of wild type virus into the host cell. The respective sense and antisense constructs were made to serve as controls, as previous work has shown that some degree of interference is possible, but that it is insufficient most of the time to reduce virus accumulation to an acceptable level. For TMV constructs, the coat protein and replicase genes were targeted for either viral coat protein-mediated resistance or a gene silencing approach. Tomato plants (30 each) have been transformed with the ToMV and PepGMV constructs and will be available within about4-5 months for assessment. Five plants each have been transformed with the two control constructs and a vector minus and insert. Tobacco plants ('Xanthi') also have been transformed with PepGMV constructs and will be assessed to assess the proof of concept. Tobacco regenerates much faster than tomato and so transformants will be available within two months to challenge inoculation with infectious clones of candidate viruses. Also, transformants will be assessed with respect to gene copy number, viral levels (accumulation) by Southern hybridization, mRNA expression (real-time PCR).

Publications

Alwang, Jeffrey, Steve Weller, Guillermo Sanchez, Luis Calderon, C. Richard Edwards, Sarah Hamilton, Roger Williams, Michael Ellis, Carmen Suarez, Victor Barrera, Charles Crissman, and George W. Norton. 2004. Chapter 5. Developing IPM Packages in Latin America, in: *Globalizing Integrated Pest Management: A Participatory Research Approach.* Blackwell Publishing.

Brown, J.K., A.M. Idris, K.M. Ostrow, R. French, and D.C. Stenger. 2004. A New World begomovirus complex: a case study of genotypic and phenotypic variation among several strains of *Pepper golden mosaic virus. Phytopathology* (in preparation).

Hamilton, Sarah and Edward F. Fischer. n.d. Labor Relations in the Nontraditional Agricultural Export Sector in Highland Guatemala. Article under review for invited special edition, *Latin American Perspectives.*

Hamilton, Sarah, Keith Moore, Colette Harris, Mark Erbaugh, Irene Tanzo, Carolyn Sachs, Linda Asturias de Barrios. 2004. Chapter 14. Evaluating Gender Impacts of IPM. In : *Globalizing Integrated Pest Management: A Participatory Research Approach.* Blackwell Publishing.
Sullivan, Glenn, James Julian, Guillermo E. Sanchez, Stephen Weller, and George W. Norton. 2004. Chapter 11. Pre-inspection IPM for Export Horticulture Markets, in: *Globalizing Integrated Pest Management: A Participatory Research Approach.* Blackwell Publishing.

ICADA/IPM CRSP publications

1. Preinspection manual in snow and sweet pea. Author: Jorge Luis Sandoval Sandoval, Guillermo Sánchez, Luis Calderón, Mayra Del Cid. Publication pending.

The following four digitalized documents were printed in the IPM CRSP/ICADA office.

2. Grafting in vegetables a potential component for integrated pest management.
Author: Luis Felipe Calderón, April 2004.

3. Biofumigation of agricultural soils
Author: Luis Felipe Calderón, May 2004

4. Biofumigation process in big areas of production.
Author: Luis Felipe Calderón, June 2004.

5. Integrated pest management in snow and sweet pea.
Author: Jorge Luis Sandoval, September 2004.

The following two promotional bulletins were printed in the IPM CRSP/ICADA office.

6. Good management practices in export crops.
Author: Jorge Luis Sandoval, December 2003.

7. Preinspection process in snow pea.
Author: Jorge Luis Sandoval, Guillermo Sánchez, Luis Felipe Calderón, Mayra Del Cid, December 2003.

Presentations and Proceedings

Nolasco, Jonathan and Jorge Sandoval. "Non-chemical alternatives to control plagues in export crops." Presentation at the AGEXPRONT Conference, November 2003, Guatemala City, Guatemala.

Sánchez, Guillermo E. Methods to Foster IPM Diffusion in Central America. Presented at the Globalizing IPM through Participatory Research CRSP meeting, Washington, DC, August 6, 2004.

Weller, Stephen. Markets and Trade: Incorporating Pre-inspection Issues in IPM for Non-Traditional Agriculture Export Crops. Presented at the Globalizing IPM through Participatory Research CRSP meeting, Washington, DC, August 5, 2004.

ICTA researchers gave four presentations on biofumigation as a method to control nematodes and weeds in the soil to the staff of private companies, universities and government institutions for promoting the use of this technique in their influence areas.

Overview of the South America Site in Ecuador

Jeffrey Alwang, Site Chair (Virginia Tech); Carmen Suárez, Site Coordinator (INIAP);
Victor Barrera, Assistant Site Coordinator (INIAP)

The Collaborative Program

This is the seventh year of activity at the South American site in Ecuador. A total of 11 major activities were conducted during the year. This site operates under a Memorandum of Understanding with INIAP, the research arm of the Ministry of Agriculture in Ecuador. A Site Coordinator and Asistant Site Coordinator manage activities under the CRSP because the crops being researched are primarily found in two locations. Dr. Carmen Suárez serves as overall Site Coordinator and focuses on the work in the lower elevations. She is a researcher at the INIAP Tropical Experimental Station at Pichilingue and coordinates plantain and agroforestry activities. Lic. Victor Barrera serves as Assistant Site Coordinator and focuses on the higher elevations, coordinating activities with potato and Andean fruits. Each activity has a leader who is responsible for interactions with his/her respective coordinators and collaborators.

The work was conducted as a collaborative effort among scientists at INIAP, the International Potato Center (CIP), the Ecuadorian National Potato Program (FORTIPAPA), PROEXANT, the International Food Policy Research Institute (IFPRI), Fundacion Maquipucuna, Eco-Salud, the Soil Management CRSP, the University of Georgia, Ohio State University, Florida A&M University, and Virginia Tech. The CRSP is developing collaborative ties with the local universities and we fund student employees and graduate students. Jointly developed collaborative research plans have allowed us to buy into ongoing research programs and initiate new projects with joint funding.

The Year 11 workplan focused on crops, pests, and constraints identified in the participatory appraisal process. Planning and collaborative research took place through: a) discussions among host country and US/international scientists at planning meetings in Ecuador and Blacksburg, VA, b) joint meetings between IPM CRSP scientists and USAID personnel in Ecuador; and c) preparation of joint host-country/US/international scientist two-page proposals.

Field research is being conducted in farmers' fields in Chimborazo, Carchi, Palora, Tungurahua, El Carmen, and Maquipucuna, with INIAP/CIP scientists visiting experiments on a regular basis. Research is also conducted on site, at Sta. Catalina, the INIAP laboratory in San Gabriel, and Pichilingue.

IPM Constraints Researched

The key constraints addressed in Ecuador in Year 11 were the need to identify and develop IPM solutions to specific pest problems in potato, Andean fruits, and plantain. Additionally, there was demand for information on mechanisms for diffusion of IPM technologies in potato. Specific major pests being addressed in the IPM program are Late Blight (*Phytophthora infestans*), Andean Weevil (*Premnotrypes vorax*), and Central American Tuber Moth (*Tecia solanivora*) in potato; Naranjilla Vascular Wilt (NVW) (caused by *Fusarium oxysporum*) and other pathogens in Andean fruits; and Black Sigatoka (caused by M*ycosphaerella fijiensis*), the bacterium *Erwina* sp., and several insect pests in plantain. The work in Maquipucuna focused on identifying and evaluating IPM solutions to pest problems in a mixed coffee and plantain system.

The Ecuador site is thus addressing some of the known production constraints of key horticultural staples in the area. *Phytophthora infestans* is a worldwide limiting factor in potato production. Andean fruits are a source of healthful food for the entire nation, and have potential for export. However, mites, nematodes, fruit and stem borers, and especially diseases such as *Fusarium* vascular wilt have made it difficult to produce these fruits economically. Vascular wilt in naranjilla has caused the collapse of the native variety in many places in Ecuador; many of which are economically and environmentally sensitive areas.

Research on naranjilla may stabilize production areas in environmentally sensitive areas along the Andean slopes. Increased production of the fruit will enhance economic stability in the northern border region of Ecuador.

Plantain is a staple food for people living in the lowland tropics. Plantain is a substitute for potatoes at lower elevations. The plantain research is especially important, as there has been very little study worldwide of IPM for plantain. An objective of the research in the plantain pest-survey is the identification and quantification of nematodes associated with this crop. This is the first such investigation of its kind of which we are aware.

Selected Research Accomplishments

This year, the Ecuadorian site has had several significant accomplishments:

Pathogenicity of *P. infestans* in potato and related species has been studied in detail using biotechnological

techniques. Molecular studies have classified these *P. infestans* populations. Pathogenicity and phylogenetical status of *P. infestans* causing late blight in other cultivated solanaceous has not been studied yet. Pathogenicity together with molecular knowledge of these new *P. infestans* populations can significantly contribute to the understanding widely the evolution of *P. infestans* in Ecuador, which in turn will allow identification of more efficient control strategies to this pathogen.

All the alternative means of controlling Central American tuber moth during seed storage and in the fields developed in the previous year were put together into field trials. This field-based study builds upon research findings from previous years, and shows significant economic gains to the farmers as well as lower health risks.

The integrated package for controlling Andean weevil in potato has been refined. The recommended package now consists of use of the biocontrol *Beauveria brongniartii* in traps and more limited use of Triflumuron applied to lower leaves of plants. This field-based study builds upon research findings from previous years, and shows significant economic gains to the farmers as well as lower health risks.

Several promising means of controlling Naranjilla Vascular Wilt (*F. oxysporum)* were tested and validated. Naranjilla grafted onto most accessions of *Solanum sessiliflorum, S. pseudolulo, S. candidum, S. hirtum, S. hirsutissimun, S. hyporodium, S. robustum* and *S. stramonifolium* appears to have promise for control of NVW. Seed disinfectation with carbendazim is a promising strategy.

Preliminary information on the socioeconomic characteristics of naranjilla producers in the Amazon basin in Eastern Ecuador was collected. Naranjilla is a major source of income among producers and diseases represent major constraints to increased production. The main crop management activities are cutting the forest, chopping the residues, planting, using stakes or plantlets that are of bad quality, from their own plantations, planting without a homogeneous and adequate seed rate. The only cultural practice is weeding. Fertilizer is applied to the foliage in a mixture with the first phytosanitary control. Yield differences and product attributes indicate significant economic returns to disease control.

The main virus diseases associated with tree tomato production in Ecuador were identified. Transmission of the viruses and their spread through fields has been studied in detail; the role of aphids in virus transmission is currently being established.

The number of fungicide applications for effective control of black sigatoka was reduced to six in plantain using a disease forecasting system, compared to ten applications made using a standard calendar-based program. A strategy for control of black sigatoka in plantain has been identified. Fungicide application techniques have been investigated and a complete IPM package is available.

Studies to determine variability between 8 isolates of the Sigatoka fungus, four each from bananas and plantain, showed significant differences in aggressiveness; evidence shows different responses to the disease from each crop.

Experiments continue to determine best management strategies against the banana stem borer (picudo). The combined effect of the pheromone Cosmo-Lure with widespread use of the enthomopathogen *Beauveria bassiana* diminish weevil population growth because insects that come close to the pheromone, even without falling into the ramp trap, get infected by the fungus.

Information on economic impact of rehabilitation and renovation of plantain have shown that either of the two alternatives are acceptable, depending on conditions. On rehabilitated plantations, IPM practices without fungicides account for 10 times higher economic return against 6 times obtained with traditional practices. If farmers decided to renovate their plantations, any of the systems (single or double row planting with medium to high IPM management practices) tested are two- to three-fold better than traditional practices. A general recommendation derived from this study is that plantain farmers may do better with IPM practices on less area and thus there is ample space to dedicate part of their farm to some other crop so they do not depend totally on plantain.

A great diversity of parasitic and predator nematodes was identified in plantain cropping systems. This diversity seems to be playing a role in controlling pest populations since the survey demonstrates that nematode constraints are a localized problem. There was, therefore, a need to explore how to increase beneficial populations in order to improve their bio-control potential. Some results show that use of N increases population of *Radopholus* spp., while the use of residue management and soil covers decreases phytoparasitic nematodes and increased beneficials.

Experiments began to identify pests and means of their control in a plantain/coffee agroforestry system near Maquipucuna. The study is providing information on appropriate IPM strategy for main crops in a very fragile area.

The activities to transfer potato technology developed by the project was intensified during year 11. Fifty-five training workshops, 18 technical speeches and 3 field days were conducted and more than 1700 actors received this information. Through 2003, 3681 potato growers

were trained in Field Schools. Training recipients are using at least one IPM component on their crops. Eighty three percent of farmers that actually participate in FFS´s know and remember IPM practices; 54% of them are using the practices learned.

Mutuality of Benefits of the Research

The results of the plantain research will have benefits in Ecuador and the region. The U.S. and Europe are becoming major importers of plantain and, as production increases, lower relative prices will encourage and expand global acceptance.

Control of pests in potatoes is a top priority for North America as well as in South America.

The work on Andean fruit is pioneering IPM methods for pest control on these important crops. Naranjilla and tree tomatoes have export potential, but exportability is being limited by diseases. Information from the project will help avoid the introduction of pathogens to other areas of naranjilla production in Ecuador and areas of Central and South America.

The socioeconomic studies will provide information related to pest management and its impacts on household economic and health well being. This information will be of use in evaluating the feasibility and impacts of IPM throughout the Andean region.

Institution Building

Collaborative research and financial support have directly benefited institutions in Ecuador. Several Ecuadorian undergraduate and graduate students are being funded through activities of the CRSP for their Independent Study theses and their MS theses from Ecuadorian universities. This system is helping the CRSP and the universities conduct research and train individuals in applied agricultural research.

Ms. S. Garces completed her graduate studies in entomology at Ohio State University. She returned to Ecuador in early 2004 and is now continuing her work at Santa Carolina experiment station of INIAP.

Ms. C. Baez is near completion on her graduate studies in Agricultural and Applied Economics at Virginia Tech. She will finish in late-2004.

Ms. M. Mauceri is near completion on her graduate studies in Agricultural and Applied Economics at Virginia Tech. She will finish in late-2004

Mr. Danilo Vera C. completed his M.Sc. studies in Vicosa University, Brazil, financed by PROMSA resources. Collaboration was developed with Profesor L. Maffia, a well known epidemiologist from Vicosa University, and with administrators and scientists from FUNDAGRO.

Richard Sandoval is finishing his studies for Agri-industry Engineering at the Natural Resources Faculty of Universidad Técnica del Norte.

Jovanny Suquillo, Patricio Gallegos and Patricia Rodríguez, trained 70 farmers/pesticide applicators, on“Solarization, production and application of Baculovirus for the control of *Tecia*”, in 4 workshops. They also gave 18 training speeches to 75 farmers/pesticide applicators about *Tecia* IPM alternatives.

Two field days were held related to tuber moth IPM, with the participation of 180 persons, where 30% were women.

Robert Andrade López, who has worked on the socioeconomic baseline for the Naranjilla study, is concluding his studies in Economics in the Economics Faculty of the Pontificia Universidad Católica of Ecuador.

In February-March and July, 2004, Colette Harris conducted a series of community-participative training workshops to INIAP Pichilingue scientists and local school teachers and farmers in El Carmen. She carried out a series of workshops at INIAP-Pichilingue on the above subjects as well as data collection and analysis. The INIAP Pichilingue team has gained confidence in the use of discovery learning methodology to transfer IPM knowledge to farmers, and a similar set of educational modules are being developed to use with cacao.

In November 2003, 2000 copies of the Pamphlet “How to know and manage the potato tuber moth,” were published.

A workshop to elaborate a new project on naranjilla was conducted in the Amazonian city of Macas. Researchers from different institutions participated in this event: Proyecto Agroforestal INIAP-GTZ, Fundación Natura, Programa Sur, Ministerio de Agricultura y Ganadería de Morona Santiago, Estación Experimental Chuquipata of INIAP and ECORAE.

A student from the Faculty of Agronomy of the Central University of Ecuador was trained and carried out research on tree tomato viral diseases. Another student from the same university is carrying out research on virus transmission and epidemiology.

A good-quality laboratory was outfitted to conduct biotechnology research at Santa Catalina/INIAP. Several local professionals have been trained in biotechnology procedures.

Networking

The IPM CRSP is part of several projects managed by the National Potato Program of INIAP. Work on potatoes is coordinated through the INIAP-PNRT Annual Plan and interacts directly with CIP, the Soil CRSP, Eco-soil, and Fortipapa.

The biotechnology research was done in collaboration with CIP. Results are being shared with Scientists of CIP as well as other scientists working with Late blight. Research is supporting a research thesis at the faculty of Agricultural Science of the Central University.

A student from the faculty of Agricultural Science of the Central University participated in biotechnology research.

The potato tuber moth investigation was carried out jointly among INIAP, IPM-CRSP, CIP, PROMSA, ECOPAR, The Municipality of Montúfar and the Council of the Peasant Communities of Montúfar.

The fruit work is being coordinated through INIAP's department of fruit culture. Other professionals from universities and in research organizations who are working on fruits regularly interact with CRSP researchers. Ongoing research on fruit is being conducted in conjunction with work on INIAP experiment stations.

Studies of biological control were conducted in collaboration with the Catholic University of Ecuador and the Investigation Support Office from France. The collaborating institutions shared information, baculovirus strains, and fieldwork.

Meetings were held for theory and practical training of INIAP technicians and of collaborating farmers. Talks about this technique were delivered to farmers participating in the Field Schools in Carchi, and to the farmers belonging to the Local Agricultural Research Committees in Chimborazo.

Training was also given to students and teachers of several education centers who visited INIAP facilities, including Central University of Ecuador, Polytechnic School of Chimborazo, Polytechnic School of the Army, Technical University of the North and the University of Quevedo.

Fruit research, along with the IPM fruit results, were presented to the following groups of students: the Central University of Ecuador; students specializing in chemistry-biology in high schools such as Hipatia Cárdenas and Inmaculada Concepción of Quito; the Polytechnic School of the Army; the Polytechnic School of Chimborazo; the University of Bolívar; and the Technical University of Ambato.

Plantain research results have been shared with INIBAP (the international banana research center) forum and INIBAP personnel. The student in charge of this research was invited to participate in a course in the Dominican Republic to demonstrate and discuss the progress of the research.

The CRSP leadership has established linkages with the USAID PRONORTE project. This project is linking producers and agribusinesses in the Northern provinces with the ultimate aim to establish a stable agricultural-based economy along the Northern border with Colombia. Several field visits were conducted by IPM CRSP host country researchers to assist the PRONORTE project in identifying potential pests. Other participants in the linkage process are CIAT, CIP, Universidad Técnica del Norte, and local and municipal governments.

In the plantain area, links between researchers and AATP´s (Private Extension Agents) have been established. These links will facilitate further work in the area.

Plantain activities have been coordinated with INIBAP. The plantain work has also involved local agricultural high schools and universities. Plantain work includes interactions with IGN (the military geographic institute), CLIRSEN (the Ecuadorian remote sensing institute), the Ecuadorian foundation for ecological studies, and others.

Activities in Maquipucuna are being conducted jointly with the University of Georgia, Fundacion Maquipucuna, and the "Choco-Andino Corridor" project, a large multi-institutional integrated project. Workshops have been held in the Biology Department of the National Polytechnic School.

Presentations

Flowers, W., Belezaca, C., Vera, D. & Echeverria, F. 2004. Amauta cacica (lepidoptera, castniidae), nueva plaga del plátano en las estribaciones andinas del Noroccidente ecuatoriano. Acepted for the XVI Internacional Congress of Acorbat. Oaxaca, México. September 26 to November 1, 2004.

Vera, D., Suárez, C. & Belezaca, C. 2004. Estrategias de manejo integrado de la sigatoka negra en plátano cv. 'Barraganete' Musa AAB) en el Ecuador. Acepted for the XVI Internacional Congreso of Acorbat. Oaxaca, México. September 26 to November 1, 2004.

Rivera, R., Suárez, C., Vera, D., Belezaca, C. & Ellis, M. 2004. Influencia del grado de tecnificación de las fincas sobre las poblaciones de fitonematodos en plátano cv. Barraganete, en Ecuador. Acepted for the XVI Internacional Congress of Acorbat. Oaxaca, México. September 26 to November 1, 2004.

Rivera, R., Suárez, C., Triviño, C. & Ellis, M. 2003. Frecuencias y densidades poblacionales de los principales nemátodos fitoparásitos del plátano (*Musa* AAB) en el Ecuador. Presented in the XII Seminario Nacional de Sanidad Vegetal. Latacunga, Ecuador. 19-21 de Noviembre, 2003

Bone, S., Suárez, C., Belezaca, C. & Delgado, R. 2003. Eficiencia de fungicidas biológicos y bioestimulantes para el control de *Mycosphaerella fijiensis* Morelet (Sigatoga Negra) en plátano Barraganete Común (*Musa* AAB). Presented in the XII Seminario Nacional de Sanidad Vegetal. Latacunga, Ecuador. 19-21 de Noviembre, 2003

Belezaca, C., Suárez, C., Cedeño, J., Carranza, I. & Delgado, R. 2003. Determinación de distancia de siembra y diseños espaciales para el manejo de Sigatoca Negra en plátano Barraganete Común (*Musa* AAB). Presented in the XII Seminario Nacional de Sanidad Vegetal. Latacunga, Ecuador. 19-21 de Noviembre, 2003

Technology Transfer Activities

Twenty eight FSs (field schools) were implemented in Ecuador's principal potato-growing regions. The FSs have trained 318 men and 120 women. More than 3,344 potato growers of Carchi and 1,237 from Bolivar, have been involved in different training events. The training activities have been performed at several levels, involving farmers and students, as well as technical personnel from governmental institutions and NGOs. Several workshops have been conducted and the methodology is being extended to other potato-growing areas of Ecuador.

In potato-growing areas, 55 training workshops, 18 technical speeches and 3 field days were conducted and more than 1700 actors received this information. Training recipients are using at least one IPM component on their crops. Eighty three percent of farmers that actually participate on FFS´s know and remember IPM practices; 54% of them are using the practices learned.

Training workshops were held at Tambohuasha and La Delicia with the participation of 40 farmers (23 women and 17 men). The topics addressed were: biological cycle, behavior, biological control, and integrated management of the Andean potato weevil.

A short-course was held for Palora's farmers regarding training on naranjilla culture and phytosanitary problems; 58 participants (including 18 women) attended this course.

A workshop to elaborate a new project on naranjilla was conducted in the Amazonian city of Macas. Researchers from different institutions participated in this event: Proyecto Agroforestal INIAP-GTZ, Fundación Natura, Programa Sur, Ministerio de Agricultura y Ganadería de Morona Santiago, Estación Experimental Chuquipata of INIAP and ECORAE.

Several field days were held in La Libertad, La Granja La Pradera of Technical University of the North, Eloy Alfaro y Yalquer, in Carchi and Imbabura. 522 persons participated; 35% were women. Field days were also held in Larcaloma and Quinua Corral, in Bolivar, with the participation of 307 persons, and 45% were women. In addition, two observation field trips were organized, related to IPM and FSs, with the participation of 137 potato producers.

An intensive course on IPM and FSs was held, targeting teachers of agro-livestock schools in Carchi.

In January 2003, 28 university students of the Agronomy Schools of the Technical University of the North and of the Catholic University of Ibarra graduated in Field School and Training of Trainers methods. In August 2003 an intensive course for students and teachers of the Catholic University of Ibarra was held.

Luis Escudero, Víctor Barrera, Richard Sandoval and Mario Freire participated as facilitators for the course, Training the Trainers in IPM, for students and teachers of high schools and universities. They trained 1,103 children, 86 housekeepers, 440 farmers/applicators, 39 university teachers, 136 high school students and 74 university students on IPM and pesticides in potato.

Carlos Monar and Angel Rea trained 174 potato producers in three workshops.

Patricio Gallegos, Patricia Rodríguez and César Asaquibay trained technicians of the INIAP UVTT–Carchi and the Local Committee of Agricultural Research (LCAR) of Monteverde, and students and teachers of several education centers.

Jovanny Suquillo, Patricio Gallegos and Patricia Rodríguez, trained 70 farmers/pesticide applicators, about "Solarization, production and application of baculovirus for the control of Tecia", in 4 workshops. They also gave 18 training speeches to 75 farmers/pesticide applicators about Tecia IPM alternatives.

Two field days were held related to tuber moth IPM, with the participation of 180 persons, where 30% were women.

In February-March and July, 2004, Colette Harris conducted a series of community-participative training workshops to INIAP Pichilingue scientists and local school teachers and farmers in El Carmen. She carried out a series of workshops at INIAP-Pichilingue on the above subjects as well as data collection and analysis. The INIAP Pichilingue team has gained confidence in the use of discovery learning methodology to transfer IPM

knowledge to farmers, and a similar set of educational modules are being developed to use with cacao.

Publications

THESES

Vera, D. 2003. Epidemiologia comparativa da Sigatoka Negra em bananeira e bananeira-da-terra no Equador. M. Sc. Thesis. Viçosa, Brasil. Universidade Federal de Viçosa.

Cabanilla, M. 2004. Evaluación económica de tecnologías para rehabilitación y renovación de plataneras y proyección del impacto económico a generar con su adopción en la zona de El Carmen, Provincia de Manabí. Tesis de Ingenieneria en Administración de Empresas Agropecuarias. Quevedo, Ecuador. Universidad Técnica Estatal de Quevedo.

Rivera, R. 2004. Determinación cualitativa y cuantitativa de nemátodos en áreas plataneras del Trópico húmedo del Litoral ecuatoriano. Tesis de Ingeniero Agrónomo. Guayaquil, Ecuador. Universidad de Guayaquil.

Training

Alvarez Danny. Colegio Técnico Agropecuario Galo Plaza. Daule. February 3 - 14. 2003. IPM practices in plantain crop.

Quinto Daniela Colegio Técnico Agropecuario Galo Plaza. February 3 - 14. 2003. IPM practices in plantain crop.

Goya Fanny. Colegio Técnico Agropecuario Galo Plaza. Daule. February 3 - 14. 2003. IPM practices in plantain crop.

Holguin Walter. Colegio Técnico Agropecuario Galo Plaza. Daule. February 3 - 14. 2003. IPM practices in plantain crop.

Rendón Fausto. Colegio Técnico Agropecuario Galo Plaza. Daule. February 3 - 14. 2003. IPM practices in plantain crop.

Desantis Guadalupe. Colegio Nacional Técnico Agropecuario Mocache. February 3 -March 5. 2003. Field Practices of IPM and handling laboratory.

Tapia Maricela. Colegio Nacional Técnico Agropecuario Mocache. February 3 -March 5. 2003. Field Practices of IPM and lab instrumental handling .

Diaz Marlon. Universidad Técnica Estatal de Quevedo. March 31 - May 2. 2003. Field Practices of IPM in plantain crop and lab instrumental handling.

Mero Loor Nelson. Universidad Técnica Estatal de Quevedo. November 10 - December 10. 2003. Practices in nematodes identification and sanity of plantain crop.

Navarrete Mercedes. Estación experimental Sto. Domingo. March - May. 2004. Biological control of black weevils, lab instrumental handling of entomopathogens.

Zaira Lopez Briones – Universidad de Guayaquil-Instituto Tecnológico Agropecuario, Vinces. Phytopathological methods and lab instrumental handling. Feb – Ag, 2004.

Geanina Oliva Palacios – Escuela Superior Politécnica del Ejercito, Santo Domingo. Phytopathological methods and Transference methods with plantain farmers. Feb- March, 2004.

Marcos Cueva Tacuri - Escuela Superior Politécnica del Ejercito, Santo Domingo. Phytopathological methods and Transference methods with plantain farmers. Feb- March, 2004.

Doris Brito Peñafiel – Escuela Superior Politecnica del Litoral, Daule. Training in biological control of Black Weevil of plantain and phytopathological methods.

Carla Salazar Peréz - Escuela Superior Politecnica del Litoral, Daule. Training in biological control of Black Weevil of plantain and phytopathological methods. March – April, 2004.

Yony Molina – Comisión Nacional del Cacao, República Dominicana. Training in identification and control of cocoa diseases, phytopathological methods and participatory methods for technological transfer in cocoa. July, 2004.

Evelyn Osorio - Escuela Superior Politécnica del Ejercito, Santo Domingo. Phytopathological methods and lab instrumental handling. In process.

Overview of the South Asia Site in Bangladesh

Edwin G. Rajotte, Site Chair (Penn State); ANM Rezaul Karim, Site Coordinator,
Horticulture Research Center (BARI)

Description of the Collaborative Program

IPM activities at the Bangladesh site were concentrated in four program areas during year 11, which was year 6 for Bangladesh. The first of these areas was vegetable crop pest survey and monitoring, the second was multidisciplinary pest management experiments, the third was laboratory, greenhouse and microplot experiments for biological control, and the fourth was socioeconomic analyses. The work was conducted as a collaborative effort among scientists at the Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI), the Bangladesh Rice Research Institute (BRRI), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), the Asian Vegetable Research and Development Center (AVRDC), the International Rice Research Institute (IRRI), the University of the Philippines- Los Banos, Penn State University, Ohio State University, Purdue University, and Virginia Tech. ANM Rezaul Karim served as Site Coordinator and Edwin G. Rajotte as Site Chair.

The Year 11 workplan focused on crops, pests, and constraints identified in the participatory appraisal process and in the previous year's crop pest monitoring. Pest management experiments and socioeconomic analyses were refined using the knowledge gained in the past five years. Planning and collaborative research work took place through: a) discussions among host country and US/International scientists at planning meetings in Bangladesh and b) preparation of joint host –country/ US/international scientist two-page proposals. Planning for future workplans also involved discussion of the plans jointly with scientists working in the Philippine site during the annual planning workshop at HRC, BARI in February 2004.

Field research is conducted in farmers' fields in Sripur of Gazipur district, and in Jessore, Comilla, Chittagong and Lalmonirhat districts, with BARI/BRRI scientists visiting experiments on a regular basis. Some research is also conducted on-station, especially varietal screening for insect, disease, and nematode resistance in eggplant, tomato, okra and pumpkin. Training takes place primarily at U.S. universities, UPLB (Philippines) and BSMRAU (Bangladesh). CARE-Bangladesh participated in the planning and field visits and teamed up with the IPM CRSP to disseminate IPM CRSP technologies in intensive vegetable growing areas through their existing extension programs. Technical Officers of CARE-Bangladesh received practical and theoretical training from IPM CRSP on the technologies. In turn, CARE officers trained their field staff and farmers and established demonstration trials on various vegetable IPM technologies.

Pest management research encompassed three major thrusts. The first thrust was a continuation of crop pest monitoring for the final year. The second thrust included various manipulations of the host plant to provide insect and disease resistance (varietal screening, rootstock grafting, hybrid production). The third thrust involved investigations of the effectiveness of various IPM tactics against key pests in various vegetable crops (IPM approach for cabbage pest control, virus infection timing, fruit fly bait trapping, soil amendments against soil-borne disease, integrated management for weeds and diseases, and biological control).

Socioeconomic studies included a continuation of the analysis to measure economic impacts of Bangladesh IPM CRSP research activities, adoption of IPM practices in different regions of Bangladesh and integration and diffusion of IPM technology.

IPM Constraints Addressed

The key constraints addressed in Bangladesh in year 11 were the need for IPM solutions to specific pest problems in vegetables and the need for information on socioeconomic factors influencing adoption of IPM. Specific major pests being addressed in the IPM program included eggplant fruit and shoot borer (*Leucinodes orbonalis*), bacterial wilt (*Pseudomonas solanacearum*) in eggplant and tomato, fruit fly in cucurbit crops, diamond-back moth and other leaf-eating insects in cabbage, soil-borne pathogens (*Fusarium* and others) and root-knot nematode in eggplant, tomato, okra and gourds, virus diseases in okra and sweet gourd, and various weeds in tomato and okra.

Selected Examples of Research Progress and Results

Detailed descriptions of research progress and results are provided in the individual institution activity reports. The following is a brief summary of research progress and the results:

Status of white fly incidence and infestation in vegetable crops**:** In recent years, white fly infestation has increased considerably damaging various vegetable crops, both by direct feeding and transmitting virus diseases. Replicated

trials conducted at Hathazari RARS and Jessore RARS of cooler months from December to February, infesting highly the crops of eggplant, cabbage, country beans, tomato and cauliflower. At Hathazari, white fly infestation levels were 3-12 times higher than that at Jessore.

IPM package for healthy and higher production of eggplant**:** Demonstration trials carried out at Jessore and Sripur (Gazipur) sites were highly successful. The IPM package consisted of (a) Use of FSB-resistant eggplant lines; (b) Eggplant grafting using resistant lines; (c) Sanitation (excising and destruction of FSB-infested twigs and fruits); (d) Soil amendment practices with poultry refuse or mustard oil cake; and (e) Two hand weedings. At Sripur, IPM fields suffered no mortality from bacterial wilt disease (BW) as compared to about 54% mortality in non-IPM fields. The eggplant crops in IPM fields produced 1.9 times more fruits per plant and about 5 times higher yield per ha. The farmers obtained 2 times higher economic returns from this practice. Similarly in Jessore, eggplant fields with the IPM package had no mortality from bacterial wilt disease, produced about 4 times more fruits per plant, 1.2 times more yield and increased farmers' income by more than 2 times.

IPM package for healthy and higher production of tomato**:** The IPM package for tomato was demonstrated at Jessore and Sripur sites. The IPM package consisted of (a) Raising tomato seedlings under fine-mesh nylon nets to protect from viruliferous white fly; (b) Tomato grafting on BW-resistant eggplant rootstocks; (c) Soil amendment practices with poultry refuse or mustard oil cake in seedbed as well as in the planting field to control bacterial wilt disease; and (d) Weed control by two hand weedings. Tomato grafting was highly compatible giving 95% success. In the Jessore site, tomato plants in IPM fields suffered only 1.5% mortality as compared to 11% mortalities in non-IPM fields. IPM fields produced 1.5 times more fruits and 1.75 times higher yields/ha, fetching the farmers about 2 times higher income. The results at Sripur were even better; tomato plants suffered no mortality as compared to about 48% mortalities in non-IPM plots. The plants of IPM fields bore 2.8 times more tomato fruits and produced 3.3 times higher yields. As a result, the farmers received over 4 times more economic returns.

IPM package for healthy and higher production of cucurbit crops: The IPM package demonstration trials for producing cucurbit crops were carried out on bitter gourd at Sitakund site (Chittagong) and on sweet gourd at the Sripur (Gazipur) and Jessore sites. The IPM package consisted of (a) Use of soil amendment practices with poultry refuse or mustard oil cake to control soil-borne disease pathogens; (b) Weed control by two hand BARI showed that the white fly incidence was higher in weeding; and (c) Use of bait traps with synthetic pheromone and mashed sweet gourd (MSG) to control cucurbit fruit fly. At Sitakund, the IPM fields of bitter gourd had only 9.8% fruit fly damage as compared to 24.3% in the fields of farmer practice that received weekly or fortnightly applications of insecticides. As a result of low fruit fly infestation in IPM fields, the yields were 2 times higher, fetching as much higher income to the farmers. By adopting the IPM package the farmers saved Tk.41,600 (US$705) per ha for crop protection. Similarly, fruit fly damages in sweet gourd crops of IPM fields were 29% in Sripur and 20.3% in Jessore as against 73% and 78.4%, respectively, in farmer practices that received 6-10 insecticide applications. The IPM fields produced 1.6 to 1.9 times higher yields, bringing about 1.2 to 1.6 times higher incomes to the farmers.

IPM package for healthy and higher production of cabbage**:** IPM package demonstration trials on cabbage production were carried out in Comilla and Jessore sites with the following the IPM treatments: (a) Use of soil amendment practices with poultry refuse or mustard oil cake in seedbeds to control soil-borne diseases; (b) Weed control by two hand weedings; and (c) Destruction of leaf-eating caterpillars by hand-picking. In Comilla, cabbage plants in IPM fields were luxuriant in growth, and suffered only 1.3% damage from leaf-eating caterpillars as compared to14% in the farmer practice that received 5- 7 insecticide applications. Due to low pest infestations, IPM fields produced 1.2 times higher yields per ha and fetched 1.6 times more income for the farmers. Similarly, IPM fields at Jessore site had only 1.2% pest damage as compared to 10% in the farmer practice that received 2 applications of insecticides and 4 handpickings. The IPM fields gave 107% higher yields per ha and produced 129% higher income for the farmers.

Pilot production of grafted tomato**:** Pilot production of grafted tomato was demonstrated in Jessore and Sripur sites. Tomato varieties, BARI Tomato-2 and BARI Tomato-9, were grafted on BW-resistant wild eggplant rootstocks (*Solanum sisymbriifolium*) and the grafting success averaged 94%. At Jessore site, only 1.3% grafted tomato plants died of BW infection as compared to 10.5% of the non-grafted ones. The grafted tomato plants produced 1.4 times more tomato fruits per plant and 1.4 times higher yields per ha. As a result, farmers received 1.6 times more profit from cultivating grafted tomato crop. At Sripur site, none of the grafted tomato plants died of BW attack, whereas the non-grafted ones suffered 45.5% mortality. The fruit bearing was 1.4 times higher in grafted tomatoes giving 1.9 times higher yield per ha and 2.7 times increased income to the farmers.

Integrated management of soil-borne diseases and weeds in tomato**:** Integration of soil amendment with decomposed poultry refuse or mustard oil cake and two hand weedings at 20 and 40 days of crop growth showed that this practice was highly effective to control the dominant weeds and the soil-borne disease pathogens when compared with that of the farmer practice. The plots with integrated management practices had about 50% less plant mortalities, 1.3 times more fruits per plant, 1.7 times higher yields per ha and produced 2.75 times higher income.

Development of eggplant varieties resistant to fruit and shoot borer (FSB): The eleven eggplant lines/varieties showing resistance to FSB during the past two years also exhibited resistance during 2003-2004 period. Among these, ISD-006, BL-009, and BL-114 were most promising in respect to FSB resistance and agronomic qualities. Two approved varieties, Kazla and Uttara, were moderately resistant, and cultivation of these varieties can bring down the FSB incidence effectively in the future.

Development of eggplant varieties resistant to bacterial wilt (BW) and root-knot nematode (RKN): Five lines were identified to be resistant to BW through evaluation of 56 eggplant lines in BW-infected sickbeds. These lines will be further evaluated for confirmation and development of BW-resistant varieties. In a separate test, 30 eggplant lines were evaluated in RKN-infested sickbed and 10 lines were selected as moderately resistant to RKN.

Development of tomato varieties resistant to bacterial wilt (BW) and root-knot nematode (RKN): Seven tomato varieties/lines were selected as resistant/moderately resistant to BW through evaluation of 25 tomato varieties/lines in artificially BW-inoculated sickbeds. Similarly, 9 varieties/lines were identified moderately resistant to RKN by testing 21 varieties/lines. Among the selected resistant materials, there were 4 recommended varieties that possess moderate resistance to BW and RKN and cultivation of these materials will gradually minimize the incidence of these pests.

Development of virus resistant pumpkin varieties: Symptomatic and ELISA tests have shown that pumpkin crops in Bangladesh are attacked and damaged by a complex of five viruses, the 'papaya ring spot virus' (PRSV) being the most serious, widespread and damaging one. Evaluation of the 28 pumpkin lines that were selected in the past year as relatively virus-resistant has shown that six lines are highly resistant to virus diseases and five of them have potential for recommendation as varieties.

Biological control of eggplant fruit and shoot borer: The eggplant FSB larval & pupal parasitoid *Trathala flavoorbitalis* and egg parasitoid *Trichogramma chilonis* have been found to be very efficient parasitoids to control the eggplant fruit & shoot borer, which is the most menacing pest of eggplant. Both of these parasitoids are widely abundant in eggplant fields. In greenhouse tests, FSB infestation was 2.5% in the presence of *Trathala flavoorbitalis* and 45.8% when *Trichogramma chilonis* was present, but FSB infestation was only 1.7% when both the parasitoids were present. The results strongly indicate that FSB can be controlled effectively by augmenting the populations of these parasitoids without the use of insecticides.

Biological control of diamond back moth of cabbage: The diamond back moth (DBM) is a menacing pest of cabbage and cauliflower. *Cotesia* sp. is an efficient larval parasitoid of DBM and it is widely present in cabbage crops in Bangladesh. This parasitoid is density dependent; that is, the higher the density of DBM the higher is the population of *Cotesia* sp. Greenhouse tests have shown that *Cotesia* sp. can parasitize about 77% DBM larvae. Withholding insecticide applications will augment and conserve the population of this parasitoid and effectively minimize DBM incidence and help control the pest in combination with other IPM practices.

Development of bioassay protocol for screening Bt toxins and evaluation of Bt (*Bacillus thuringiensis*) gene proteins against eggplant FSB: A biotechnological program has been taken up, as an ultimate aim, to transfer the Bt gene proteins to commercial eggplant varieties for controlling the menacing FSB. As the first step to achieve this objective and to mass-rear FSB larvae in large numbers, a protocol was successfully developed to mass-rear FSB larvae in an artificial diet. As the second step, a Bt protein crystal (BGSC Strain No. 4D1) having the Cry1 gene was collected from the *Bacillus* Genetic Stock Center, USA and was cultured in the laboratory successfully. The cultured Bt gene will be evaluated against the FSB larvae to determine its effectiveness.

On-farm demonstrations for diffusion of IPM CRSP technologies: The results of on-farm demonstrations on soil amendment practices with poultry refuse and mustard oil cake on cabbage, eggplant and tomato in Comilla and Lalmonirhat districts created a great impact among the farming community showing their interest to adopt the practices. Soil amendment practices reduced the plant mortalities by more than 60% when compared with that of the farmer practice, with an average of 22% increased yields and 20% higher income. Similarly, the results of bait trapping for fruit fly control in cucurbit crops was carried out in sweet gourd and bitter gourd crops with asynthetic pheromone and mashed sweet gourd (MSG)

were highly impressive. Bait trapping reduced fruit fly damage by an average of 69% in bitter gourd and 62% in sweet gourd fields, thereby producing 34% additional yields in bitter gourd and 24% in sweet gourd and bringing about more than 1.5 times higher income for the farmers. The farmers learned improved methods of vegetable cultivation, particularly the benefits of IPM practices without interventions of pesticide use. The average adoption rate in Comilla and Lalmonirhat was 85% for soil amendment practice and 90% for bait trapping.

Mutuality of Benefits of the Research

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

Institution Building

Funds were provided for vehicle repair and maintenance, and rental to facilitate transport to and from research sites. Expenses for greenhouse and laboratory renovations, purchase of computers, and various supplies were provided. US scientists provided research supplies, such as ELISA kits with virus antisera, synthetic pheromone for cucurbit fruit fly, and sticky traps for white fly monitoring. Bibliographies prepared at Penn State University were also sent to the scientists.

Human Resource Development

One Bangladeshi student, Nazrul Islam, will complete his Ph. D. degree program in weed science in October 2004 from UPLB in the Philippines. One Bangladeshi student, F. Zaman, is continuing his Ph. D. degree program at Penn State in Entomology. One Bangladeshi student, Ms Nahar, completed research work at Ohio State in support of her Ph. D. degree and presently taking courses at the BSMR Agricultural University in Bangladesh. Two Bangladeshi scientists, M. Nasiruddin and Shawquat Ali Khan, completed a three-week study tour-cum-training on vegetable IPM and weed science at PhilRice/UPLB in the Philippines. Three Bangladeshi scientists, M. Al-Amin, Shahabuddin Ahmad and Syed Nurul Alam, completed a month-long training on eggplant biotechnology at Tamil Nadu Agricultural University, India. Two Bangladeshi scientists, Salim Reza Mollik for an MS in horticulture and Khorsheduzzaman for a PhD in entomology, are pursuing their degree studies at the BSMR Agricultural University in Bangladesh. IPM CRSP is also providing financial support for three Bangladeshi MS students, Abu Jafar Alponi (BAU), Rayhanul Islam and Mahmuda Akter (BSMRAU), for their MS thesis research on vegetable IPM socio-economic studies. One US student, Jacob Ricker- Gilbert, worked on his masters thesis (agricultural economics) assessing the cost effective methods for dissemination of IPM technologies. He surveyed and collected data from different areas of Bangladesh.

Scientist travel

S. K. De Datta travelled to Bangladesh in December 2003 to review research progress and hold meetings with USAID, BARC, BARI, BRRI. E. A. Heinrichs, G. Norton, E. Rajotte, S. Miller and Aurora Baltazar travelled to Bangladesh in February 2004 to review research results and help plan additional research. They also attended a farmer motivational meeting at Jessore site. R. Karim along with Mozammal Hoque, M. A. Rashid (BARI-IPM CRSP scientists), and Nils Den Tex (CARE-Bangladesh Technical Coordinator) travelled to the Philippines to attend a two-day regional workshop of the IPM CRSP in Manila and presented posters and papers on vegetable IPM technologies and their dissemination in Bangladesh. R. Karim and Syed Nurul Alam travelled to USA to participate in a two-day workshop on ‘Globalizing IPM through participatory research: Lessons from the IPM CRSP’ held at Hotel Washington, Washington, D.C., and presented the IPM CRSP achievements in Bangladesh.

Networking Activities

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

Research Accomplishments

Research progress and key results for the past year are summarized above. Among those listed, the success with the eggplant and tomato grafting program against bacterial wilt, soil amendment practices to control soil-borne diseases in vegetables, IPM practices for cabbage pest control, and the use of bait traps to reduce fruit fly in gourds are particularly significant, as were the results of biological control of eggplant fruit and shoot borer, and diamond back moth of cabbage, and cost effective integrated weed and disease management practices in vegetable crops.

Technology Transfer

During the visit of the overseas scientists to Gaidghat site at Jessore, as many as 150 farmers gathered to observe the performance of IPM practices conducted by the local farmers on eggplant, tomato, cabbage and cucurbit crops. After the field visit, farmers joined a discussion meeting and exchanged their views with other farmers practicing the IPM practices and the IPM CRSP scientists. The farmers were highly impressed with the results and exhibited keen interest to adopt the IPM practices. Additionally, a motivational training for 145 bitter gourd farmers was organized at Sikanderpur of Jessore (near Gaidghat site). Scientists of the BARI Entomology Division associated with the IPM CRSP explained the various vegetable IPM technologies developed so far. The farmers of Gaidghat area who have been participating in IPM CRSP programs also shared their experience with the attending farmers. The farmers showed keen interest in IPM technologies and requested the scientists to help them adopt the technologies.

A day-long farmer field day was conducted at Sitakund site of Chittagong. The BARI Director (Training & Communication) attended as the chief guest. As many as 150 farmers, villagers and NGO personnel participated and visited the fields to observe the bait trapping technique of controlling fruit fly in bitter gourd by using synthetic pheromone and mashed sweet gourd (MSG) traps. The IPM CRSP-BARI entomologists and the farmers who adopted the technology clarified various aspects of the technique to the participating farmers. The farmers were highly impressed and expressed their eagerness to adopt the technique in their cucurbit crops.

Teaming up with CARE-Bangladesh, IPM CRSP-BARI scientists trained 22 CARE officers (Training of Trainers-TOT) in order to disseminate vegetable IPM technologies through their on-going extension programs. In turn, CARE has trained 215 field officers who have so far imparted training to as many as 47,600 male and female farmers in Rangpur-Dinajpur region on various IPM technologies. Until now, they have established demonstration plots on different technologies in 1904 'Farmer Field Schools' (FFS), involving 318 farmers in sawdust burning practice, 430 farmers in poultry refuse use, 376 farmers in mustard oil cake use, 47 farmers in eggplant grafting practice, 705 farmers for mashed sweet gourd (MSG) bait traps, and 42 farmers for pheromone bait trap use.

Presentations in National and International Meetings

M. A. Rashid, Shahabuddin Ahmad, Ataur Rahman, Bahauddin Ahmed, A. N. M. R. Karim, and E. G. Rajotte. 2004. Grafting technique for controlling bacterial wilt disease in eggplant and tomatoes. Poster presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

M. M. Hoque, M. Nazim Uddin, S. R. Mollik, Mahbubur Rahman, A. N. M. R. Karim, E. G. Rajotte and G. C. Luther. 2004. IPM approach for controlling lepidopteran pests of cabbage in Bangladesh. Poster presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

S. N. Alam, M. A. Rashid, A. K. M. Khorsheduzzaman, H. S. Jasmine, N. A. Sultana, A. N. M. R. Karim, E. G .Rajotte and G. C. Luther. 2004. Development of eggplant varieties resistant to fruit and shoot borer and other pests. Poster presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

S. N. Alam, A. K. M. Z. Rahman, A. K. M. Khorsheduzzaman, A. N. M. R. Karim, E. G. Rajotte, G. C. Luther and N. S. Talekar. 2004. Parasitism efficiency of two parasitoids, *Trathala flavoorbitalis*, and *Trichogramma chilonis*, on *Leucinodes orbonalis* Guenee in Bangladesh. Poster presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

M. Nasiruddin, S. N. Alam, A. K. M. Z. Rahman, A. K. M. Khorsheduzzaman, H.S. Jasmine, A. N. M. R. Karim, and E. G. Rajotte. 2004. Integrated management of cucurbit fruit fly, *Bactrocera cucurbitae* in bitter gourd using magic traps in Bangladesh. Poster presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

ASIAN REGION

A. N. M. Rezaul Karim. 2004. The vegetable industry in Bangladesh: Critical IPM needs. A paper presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

A. N. M. Rezaul Karim. 2004. Implementation of the IPM package for eggplant production. A paper presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

A. N. M. Rezaul Karim. 2004. Magic traps and cottage industries transforming pest management in Jessore, Bangladesh. A paper presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

Mozammal Hoque, M. Nazim Uddin, S. R. Mollik, Mahbubur Rahman, A. N. M. R. Karim, E. G. Rajotte and G. C. Luther. 2004. IPM approach for controlling lepidopteran pests of cabbage in Bangladesh. A paper presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

M. A. Rashid, Shahabuddin Ahmad, Ataur Rahman, M. A. Goffar, Bahauddin Ahmed, A. N. M. R. Karim and E. G. Rajotte. 2004. Grafting of eggplant and tomatoes: An Effective technique to control bacterial wilt disease and achieve high yields. A paper presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

Nils Den Tex. 2004. The vital role of NGOs: Amplifying the IPM message through CARE's smallholder pest management program in vegetables. A paper presented at the Asian Regional Workshop of IPM CRSP, held at the New World Renaissance Hotel, Manila, Philippines, June 29-30, 2004.

Highlights of the Southeast Asia Site in the Philippines (2003-2004)

Sally Miller, Site Chair (Ohio State University)
Herminia R. Rapusas, Interim Site Coordinator (PhilRice)

The Collaborative Program

IPM activities in the Philippines site during Year 11were concentrated in five program areas:

- multi-disciplinary on farm pest management experiments
- multi-disciplinary laboratory, greenhouse and microplot experiments
- biotechnology projects
- IPM technology transfer and training
- social and economic analyses

The work in the Philippines site was done as a collaborative effort among scientists of the Philippine Rice Research Institute (PhilRice), the University of the Philippines at Los Baños (UPLB), the International Rice Research Institute (IRRI), the Asian Vegetable Research and Development Center (AVRDC), Ohio State University, Penn State University, Virginia Tech., and Tamil Nadu Agricultural University (India).

Activities for Year 11 focused on the transfer of IPM CRSP technologies developed for rice-based crops, particularly onion and eggplant, biotechnology activities on the development of transgenic *Bt* eggplant to manage the eggplant fruit and shoot borer and characterization of *Ralstonia solanacearum* strains. A wrap-up of all field and laboratory studies was undertaken and the Philippines site hosted a regional symposium on IPM CRSP activities. Planning and collaborative research efforts for the year were accomplished through discussions among US, Philippines and other cooperating agencies at a planning and review meeting in the Philippines.

Field experiments were conducted in Bongabon, and Talavera, Nueva Ecija, at the PhilRice Central Experiment Station and in Asingan, Pangasinan. Laboratory experiments were conducted at UPLB and at PhilRice.

Spoladea recurvalis, an insect pest of horse purslane (Trianthema portulacastrum) was an effective biological control agent against this common and problematic weed. In experiments conducted at the NOGROCOMA Demo Farm in Bongabon, Nueva Ecija from January to April 2004, At 24 hours after release of the larvae, 16% of the leaves of the horse purslane plants were eaten by the larvae 24 hours after release, which increased to 24% within two weeks after release. The time required for follow-up handweeding operations decreased with increasing numbers of larvae released. Both insect-treated and herbicide-treated plots yielded comparably.

At the end of the fourth crop in a rice-onion cropping system over 2 years (2003-04), stale seedbed treatment reduced tuber and shoot populations of the highly damaging weed purple nutsedge by 90% compared to the first crop. This treatment reduced weed control costs by 30 to 90%, increasing net incomes by 20 to 27% over those of farmer's practice, pre-plant and post-plant herbicide treatments and handweeding. Yield reductions in non-weeded plots were greater in onion than in rice. The stale seedbed technique is a multi-season approach that is more effective in the long run than single season approaches of herbicide applications and handweeding.

A participatory rural appraisal (PRA) was conducted in Mindanao in collaboration with the Growth and Equity in Mindanao Project (GEM2 funded by USAID) in anticipation for an expansion of IPM CRSP in other vegetable areas in the Philippines.

IPM Constraints Researched

Key constraints to IPM in the Philippines addressed during year 11 were:

- absence of economical IPM solutions for specific pests;
- inadequate basic understanding of the biology of specific pests;
- inadequate knowledge on sources of germplasm for resistance to insects, pathogens and nematodes;
- absence of knowledge about policies, sociocultural beliefs and perceptions, regulations and other factors influencing pest management practices.

Specific major pests addressed in the IPM program for onion are the insect pests - cutworms and armyworms (*Spodoptera* spp.), leafminer (*Liriomyza trifolii);* disease organisms- root knot nematode (*Meloidogyne graminicola*, bulb rot (*Fusarium* spp.), pink root (*Phoma terrestris*), anthracnose (*Colletotrichum gloeosporioides*); post harvest diseases caused by *Burkholderia cepacia*, *Fusarium* sp. and *Aspergillus* spp.; weeds – *Cyperus rotundus* and *Trianthema portulacastrum.* In eggplant, fruit and shoot borer (*Leucinodes orbonalis*), leafhoppers (*Amrasca biguttula*) and bacterial wilt (*Ralstonia*

solanacearum) were studied. Characterization of *Ralstonia solanacearum* and *Bt* eggplant transformation for eggplant shoot and fruit borer resistance were likewise conducted.

Research Highlights

Field and laboratory/greenhouse experiments

The frequency of insecticide application for cutworms/armyworms was reduced by 30% over the farmer's practice by using sex pheromone trap catches as the basis for timing insecticide applications. Percent reduction was lower this year than last year (>40%) because of high incidence of cutworm/armyworm infestation. Although the difference in yield between the researcher's plots and the farmer's plots was not significant, the net income from the researcher's plots was higher due to reduced insecticide input costs compared to the farmer's practice.

Six species of parasitoids were reared from *L. trifolii* larvae collected from the field. Average parasitism was 24, 26 and 28% for Nueva Ecija, Nueva Vizcaya and Pangasinan, respectively. Significantly more *L. trifolii* adults were attracted to and caught by the yellow sticky board traps compared to the blue, purple and white traps. Hence, mass trapping of adults with yellow sticky traps can be used in combination with the parasitoids for efficient management of *L. trifolii* in onion and other vegetables.

VAM enhanced the growth and yield of 'Yellow Granex' onions at low N and available P in the soil. Also, VAM increased tolerance of 'Yellow Granex' to pink root and root-knot diseases but this effect was not observed in "Red Creole'. The application of the recommended fertilizer rate for onion is not necessary with the application of VAM. VAM applied on seedbeds is very economical and environment-friendly.

Anthracnose of onion can be effectively managed through reduced nitrogen application and proper spacing. Plant spacing at 10cm x 15cm gave higher yields than spacing at 18cm x 20 cm. The application of Mancozeb against anthracnose was not critical for yield of onion, hence its application can be minimized, reducing input costs and hazard to the environment.

'Red Creole' is more resistant than 'Yellow Granex' to onion bulb rot disease under cold and room temperature storage. Storage life of 'Yellow Granex' and 'Red Creole' at room temperature was only four and five weeks, respectively, indicating that room temperature was not suited for long time storage. Both varieties though can last up to 13 weeks under cold storage. Activity of bulb rot causing pathogens was retarded at cold temperature storage. *Fusarium* sp., *Burkholderia cepacia* and *Aspergillus niger* were the predominant pathogens in 'Yellow Granex'.

Weekly application of insecticide was not effective in controlling *Leucinodes orbonalis*, the eggplant fruit and shoot borer, and is not an assurance for higher yield of marketable eggplant fruits. Weekly removal of damaged shoots and fruits every week was more economical and environment-friendly than the use of insecticides.

Ten promising lines of eggplant were screened for leafhopper and fruit and shoot borer resistance in the field and greenhouse. Results showed that 'A-300 ('Tisay'), 'Abar' and 'EG-203' were resistant to the leafhopper, *A. biguttula*, but '544 White'' was susceptible. Some fruits of 'A-300' though resistant, had a few borer holes or tunnels dye to fruit and shoot borer feeding. 'Abar' was susceptible to the fruit and shoot borer.

'EG-203', an eggplant variety resistant to bacterial wilt, was used as rootstock in grafting 'Casino' and 'Nueva Ecija Green' varieties and planted in farmers' fields in Pangasinan. Results showed that the grafted 'Casino' and 'Nueva Ecija Green' gave 50% and 43% bacterial wilt control, respectively. Likewise, 13 eggplant cultivars were evaluated for resistance to the Asingan isolate of *Ralstonia solanacearum* in the greenhouse. 'EG-195', 'EG-203', and 'EG-210' showed 26, 40, and 40% wilt infection, respectively. *S. sissymbrifolium* had only 21% infection while 'CO2' isoline had 83.8% bacterial wilt infection.

A survey of bacterial wilt incidence conducted during wet and dry seasons in four provinces namely Pangasinan, Nueva Ecija, Batangas and Quezon showed disease incidence ranging from 0-95%. Of 610 eggplant samples collected, 80.6 % (492 samples) were positive to the ELISA test and only 57% (353 samples) were recovered by the culturing method. Of 28 apparently healthy eggplant samples during the dry season, 42.9% were negative to ELISA and the culturing method, 42.9% positive to ELISA but not recovered by culturing, 14.3% positive to both ELISA and culturing. Among the healthy plants collected during the wet season, 79.2% were negative to both ELISA and isolation and 17.4% were recovered by ELISA alone. Biochemical tests of the 303 *R. solanacearum* isolates collected during the survey showed that 74 (24.4%) belonged to biovar 3 and 229 (75.6%) were of biovar 4. Molecular characterization of 243 isolates is being conducted and an aggressiveness test is on-going at IPB, UPLB.

Six eggplant genotypes were identified for transformation and evaluated for their morphological traits. These were 'A-300', 'EG-203', 'Mara', '89-002', 'Batangas Long Purple' and 'Dumaguete Long Purple'. 'CO2' from India was included in the characterization. An initial transformation protocol was developed. The material

transfer agreement (MTA) for the *Bt* genes was signed between the University of Ontario, Canada (the source of the Bt genes) and PhilRice (the recipient). The *Bt* genes (*cry* 1Ab and *cry* 1Ac) will be sent to PhilRice very soon. The proposal for the permission to conduct the eggplant *Bt* transformation research is being prepared for submission to the National Committee on Biosafety of the Philippines. The procurement of some details on the plasmid constructs took some time, hence, the delay in the submission of the proposal. Likewise, *Cry* 2Aa protein was received from TNAU and will be used for bioassay to *L. orbonalis* as soon as the mass rearing program produces suffient insects to conduct the tests.

Participatory Rural Appraisal (PRA) in Mindanao

The PRA in Mindanao showed that tomatoes, sweet peas, beans, bell pepper and crucifers are the common vegetables grown by farmers. Vegetable farmers in major producing areas in Mindanao have low knowledge on IPM in vegetables. Application of chemical insecticides and fungicides is the most prevalent means of controlling insects and diseases. Scheduled weekly spraying is practiced by most farmers. There is need to train farmers in Mindanao on vegetable pest management.

Economic Impact analysis

Economic impact analysis on the use of sex pheromones traps to time insecticide application showed that spraying at 7-9 days after peak of trap catches of cutworm/armyworm is the most economical management strategy although spraying at 5 days after peak of trap catches was most effective in controlling the pest. Sex pheromones, however, are presently not available in the Philippine market. There is evidence that farmers will adopt sex Pheromone technology if this bio-agent is made available.

The effect of Mancozeb on anthracnose was not apparent in the study conducted. However, decreasing the nitrogen application by half the recommended rate provided an increase in yield and an incremental increase in income. There is a need to formulate a location-specific fertilizer rates for onion.

VAM increased bulb size in 'Yellow Granex' and 'Red Creole' onion, especially in soil infested with the root knot nematode. Reducing the nitrogen applied in onion by half the recommended rate and applying VAM instead provided lower yield but higher income in 'Red Creole, implying a cost-reducing effect of the technology. For 'Yellow Granex' the effect of VAM could not be isolated since plots applied with half and full the recommended rate and supplemented with VAM and plots applied with half the recommended rate but not supplemented by VAM all obtained higher yields than the control plots. Benefits greatly depend on the indigenous N, P and K in the soil.

Sun-drying before cold storage of onion is a viable pre-storage curing alternative. 'Red Creole' is more profitable for cold storage than 'Yellow Granex' because it demands a higher off-season price than the latter.

A combination of mechanical and chemical methods of weed control was comparable in yield and net income to both purely chemical and mechanical methods in two locations. Therefore, choice of the method to control nutsedge depends on the availability and cost of material and labor inputs. Keeping the onion field weed-free by handweeding provides the highest yield and net income, followed by stale seedbed method either in combination with mechanical or chemical control. Chemical control alone is less profitable.

Weekly removal of damaged shoots and fruits and weekly application of Brodan for the control of the eggplant fruit and shoot borer gave the same results in terms of profitability. However, if health and environment costs are included, the weekly removal of damaged fruits and shoots is more advantageous. A combination of these two strategies is also economical.

Grafting 'EG-203' with 'Casino' to manage bacterial wilt showed promise in increasing yield levels in eggplant. However, the additional cost incurred in grafting eggplant is currently very high and cannot be covered by the value of the additional yield. The technology will be profitable and can be introduced in areas where bacterial wilt is a serious problem.

Village level integration of IPM technologies in rice-onion cropping systems

The village level integration of IPM technologies was conducted in seven villages in four municipalities of Nueva Ecija and one in Pangasinan. There were 77 IPM adopters and 35 non-IPM adopters that were monitored during the season. The alternative IPM strategies tested were cultural weed management practices like hull burning and stale seedbed techniques followed by one herbicide and one handweeding; no insecticide application during the first 20 days after transplanting; insecticide application based on damage levels and sex pheromone trap catches; application of Vesicular Arboscular Mychorrhyzae (VAM) in seedbeds and root-dipping of seedlings in Trichoderma spore suspension before transplanting.

Results indicate that with the proper integration of sound pest management practices, farmers can generate higher yield and income compared to their conventional practices. The integration of proper IPM practices resulted in the average reduction of insecticide application

by 60%, fungicide application by 67% and herbicide application by 4% compared to the farmer's practice and non-IPM. The cost of insecticide was reduced by 50%, fungicide cost by 70% and herbicide cost by 17%. Onion yield increased by 13% and 27% compared to the non-IPM and farmers' practice, respectively. On the average in all sites, net income went up by 20% and 39% over the non-IPM and farmer's practice, respectively. These results are consistent with those obtained from 2001 to 2003 in San Jose and Bongabon, Nueva Ecija.

With the involvement of farmers in developing IPM technologies, the time to adopt such technologies is shortened. Likewise, farmers can readily understand the scientific basis as to why these new alternative technologies are better in terms of increasing yield, reducing production costs as well as reducing their health risks associated with pesticide application. These encouraging results may pave the way for a faster dissemination of IPM technologies to other areas in the country where onion is widely grown.

IPM farmer cooperators attended the season long training (FFS) on onion IPM. Scientists of different disciplines together with IPM CRSP staff served as lecturers and resource persons during the training. IPM CRSP staff also served as facilitators and were assisted by Agricultural Technicians from the concerned LGUs. Seventy-seven participants graduated in the FFS.

Before the end of the onion cropping season, two Farmers' Field Days were conducted, one in San Francisco, Sto. Domingo with some 300 participants and the other in Bongabon with about 150 participants. Farmers from the other project sites as well as farmers from neighboring villages attended the field days. This activity was conducted to showcase the results of the IPM technologies in the farmer cooperators' fields. During the field days, participants were briefed in the field after which they were gathered together in a designated assembly area where discussions and an open forum were conducted. Scientists from different disciplines were invited as resource persons. These activities were attended by Municipal/City officials and staff of other LGUs

Mutuality of Benefits of the Research

Most of the pest problems addressed in the Philippines site are widespread throughout Asia and also occur in other parts of the world. Strategies developed to manage these pests economically and sustainably can thus be applied to other countries. IPM strategies developed for onion and eggplant are particular examples. We continue to cooperate with IPM CRSP Bangladesh, the biotechnology group of TNAU, AVRDC and other stakeholders. Economic and social impact analysis on some strategies like the use of sex pheromone traps to time application of insecticides are indicative that they are socially acceptable and economically beneficial. These strategies are likely to benefit farmers in other Asian countries and have the potential to be adopted in other regions. The application of VAM and *Trichoderma* sp. (T5 isolate) for the management of soil-borne pathogens are likely to be adopted by farmers producing onion and other vegetables. The village level integration of IPM technologies strategy was found to be effective in disseminating the technologies, hence, this could also be adopted in other areas and in other related USAID projects in the Philippines as well, like the GEM2 project in Mindanao. The encouraging results of the village level integration of IPM in rice-onion cropping systems may pave the way for a faster dissemination of IPM technologies to other areas in the country where onion is widely grown.

Institution Building

Funds were provided for long-term rental of a vehicle for travel to and from research/activity sites. US scientists also provided research supplies to the Philippines site. Approximately 50% of the total Philippines site budget was allocated to PhilRice and cooperating institutions in the Philippines. Technology transfer and IPM CRSP expansion studies were jointly funded by PhilRice as part of its current mission to include vegetable IPM as a component of its rice-based farming systems program.

Training - Irene Tanzo of PhilRice is pursuing a PhD degree in rural sociology at Penn State.

Networking

Networking is accomplished through institutional collaboration between PhilRice, UPLB, CLSU, LSU and other agricultural colleges in the Philippines. PhilRice is part of the Department of Agriculture (DA) and its national IPM program coordinates with IPM CRSP.

An "Asian IPM CRSP Regional Workshop: Impacts and Lessons Learned" was conducted in the Philippines and hosted by PhilRice. Participating scientists represented IPM CRSP USA, Bangladesh, India, Asian Vegetable and Research and Development Center, Philippines, Department of Agriculture- Philippines, PCARRD, UPLB, IRRI, Fertilizer and Pesticide Authority (FPA), Bureau of Plant Industry (BPI), CropLife Philippines, National Onion Growers Cooperative and Marketing Association (NOGROCOMA), Philippine Rural Reconstruction Movement (PRRM), Growth and Equity in Mindanao (GEM2) , Local Government Units (LGU) and farmers. Some 90 participants attended this workshop.

The impacts and lessons learned from the IPM CRSP Project were documented and plans to strategize on how to promote the technologies were developed. The involvement of several stakeholders in the workshop, the private and government sectors, the LGUs in particular, led into the identification of the possible roles that each sector can play in the promotion of vegetable IPM in the country. Experiences in other countries like Bangladesh and India were shared by the participants from these countries.

Dr. S. K. De Datta traveled to the Philippines to visit project sites and met with farmer cooperators in April 2004.. He came to receive an Award given by the Philippine Government for his outstanding accomplishments in the field of agriculture.

Dr. E. A. "Short" Heinrichs also traveled to the Philippines in February 2004 to visit project sites and meet with farmer cooperators. He also attended and participated in a farmers' field day at one of the sites.

Dr. Leocadio S. Sebastian and Dr. Aurora Baltazar attended the IPM CRSP symposium in Washington D. C., Aug. 5-6, 2004.

Dr. Soledad M. Roguel was on a Fulbright Visiting Research Scholarship at Penn State and University of California from October 2003 to April 2004.

Regional networking was also accomplished by attendance and presentation of papers by IPM CRSP scientists at international, regional and national meetings.

Presentations

Poster Presentations

E. C. Martin, A. M. Baltazar, J. M. Ramos, R. P. Robles, S. K. De Datta, L. T. Kok, and E. G. Rajotte. 2004. Efficacy of Spoladea recurvalis as biological control agent against *Trianthema portulacastrum* Linn. Presented during the 35Th Anniversary and Annual Convention of the Pest Management Council of the Philippines, Iloilo City, March 16-19, 2004; 17th National R&D Review and Planning Workshop held in PhIlRice in April 13-15, 2004; Asian Regional IPM CRSP Workshop Impacts and Lessons Learned held in New World Renaissance Hotel, Makati City in June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC), PhilRice, August 3-4, 2004.

Baltazar, A. 2004 Taming the world's worst weed: lessons from onion.. Presented during the Asian Regional IPM CRSP Workshop Impacts and Lessons Learned held in New World Renaissance Hotel, Makati City June 29-30, 2004.

G. S. Arida, B.S. Punzal, A.A. Duca and E.G. Rajotte. 2004. Management of *Spodoptera litura* (F.) and S. exigua (Hubner) in Onion by Mass Trapping and Timing of Interventions in Farmers' Fields. Presented during the 35th Anniversary and Annual Convention of the Pest Management Council of the Philippines, Amigo Terrace Hotel, Iloilo City, March 16-19, 2004; 17th National R&D Meeting. PhilRice, Maligaya, Science city of Munoz, Nueva Ecija. 13-15 April 2004; Asian Regional IPM CRSP Workshop Impacts and Lessons Learned held in New World Renaissance Hotel, Makati City in June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC). PhilRice, Science City of Munoz, Nueva Ecija. Aug. 3-4, 2004

Punzal, B. S.,G. S. Arida, A. A. Duca and E. R. Tiongco. 2004. Parasitoid abundance, incidence of larval parasitism and effect of trap color on the attraction of the onion leafminer, *Liriomyza trifolii* (Burgess). Presented during the 35Th Anniversary and Annual Convention of the Pest Management Council of the Philippines, Amigo Terrace Hotel, Iloilo City, March 16-19, 2004; 17th National R&D Meeting. PhilRice, Maligaya, Science city of Munoz, Nueva Ecija. 13-15 April 2004; Asian Regional IPM CRSP Workshop Impacts and Lessons Learned held in New World Renaissance Hotel, Makati City in June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC), PhilRice, August 3-4, 2004.

M.S.V. Duca, Alberto, R.T., S.E. Santiago and S.A. Miller. 2003. Integrated management of anthracnose (*Colletotrichum gloeosporioides*), a disease of increasing importance in onion. Poster presented during the 17th National Rice R & D Conference, 13-15 April 2004, PhilRice, Maligaya, Science City of Muñoz; 35th Pest Management Council of the Philippines Conference, Amigo Terrace Hotel, Iloilo City, March 16-19, 2004 and Asian Regional IPM CRSP Workshop:Impacts and Lessons Learned, New World Renaissance Hotel, Makati City, June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC). PhilRice, Science City of Munoz, Nueva Ecija. Aug. 3-4, 2004

S.E. Santiago, D.T. Eligio, R.T. Alberto and S.A. Miller. 2003. Effect of Nitrogen on Bulb Rot Incidence in Onion during Storage. Retarding Bulb Rot Incidence in Onion with Selected Curing and Storage Methods. Poster presented during the 17th National Rice R & D Conference, held in PhilRice, Maligaya, Science City of

Muñoz; 35th Pest Management Council of the Philippines Conference, Amigo Terrace Hotel, Iloilo City and Asian Regional IPM CRSP Workshop:Impacts and Lessons Learned, New World Renaissance Hotel, Makati City, June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC). PhilRice, Science City of Munoz, Nueva Ecija. Aug. 3-4, 2004

Gergon, E. B., S. A. Miller, J. M. Halbrendt, and R. G. Davide. 2004. Root-knot disease of onion: Occurrence, varietal reaction, and effect on growth and yield of 'Yellow Granex 429'. Asian Regional IPM CRSP Workshop:Impacts and Lessons Learned, New World Renaissance Hotel, Makati City, June 29-30, 2004.

Gergon, E. B., S. A. Miller, J. M. Halbrendt, and R. G. Davide. Management of root-knot disease of onion (*Allium cepa* L.) caused by *Meloidogyne graminicola*, Asian Regional IPM CRSP Workshop:Impacts and Lessons Learned, New World Renaissance Hotel, Makati City, June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC). PhilRice, Science City of Munoz, Nueva Ecija. Aug. 3-4, 2004

Gergon, E. B., M. B. Brown, and S. A. Miller. Influence of mycorrhizal fungi on growth and yield of onion (*Allium cepa* L.) in *Meloidogyne graminicola*-infested soil. Asian Regional IPM CRSP Workshop:Impacts and Lessons Learned, New World Renaissance Hotel, Makati City, June 29-30, 2004.

M. B. Brown, E. B. Gergon, E. M. Luis, E. H. Lales, C. S. Escaño, A. M. Castro, M. M. Antolin, and S. A. Miller. Utilization of vesicular arbuscular mycorrhizae in vegetable production Asian Regional IPM CRSP Workshop:Impacts and Lessons Learned, New World Renaissance Hotel, Makati City, June 29-30, 2004; 15th Regional Symposium on Research and Development Highlights. Central Luzon Agriculture and Resources Research and Development Consortium (CLARRDEC). PhilRice, Science City of Munoz, Nueva Ecija. Aug. 3-4, 2004.

Paper Presentations

Arida, G. S. and H. R. Rapusas. 2004. PhilRice-IPM CRSP Experience in Eggplant IPM. Presented during the Eggplant IPM Workshop held at Lizland Hotel, Undaneta City. April 20-21, 2004.

G. S. Arida, B.S. Punzal, A.V. Duca and E.G. Rajotte .2004. Implementation of IPM Package for Insect Pests of Onion. Paper presented in the Asian Regional IPM Workshop. June 29-30, 2004. New World Renaissance Hotel, Makati City, Metro Manila, Philippines.

Catudan, B., R. Relado, E. Gergon, and H. Rapusas. Assessment of pest management practices and problems on major vegetables grown in Mindanao. Paper presented during the Asian Regional IPM CRSP Workshop Impacts and Lessons Learned, June 29-30, 2004, New World Renaissance Hotel, Makati City.

Casimero, M. C. and H. R. Rapusas. Village level integration and training program. Paper presented during the Asian Regional IPM CRSP Workshop Impacts and Lessons Learned, June 29-30, 2004, New World Renaissance Hotel, Makati City.

Roguel S. M., R. Relado and R. Malasa. Social impacts of vegetable IPM technologies. Paper presented during the Asian Regional IPM CRSP Workshop Impacts and Lessons Learned, June 29-30, 2004, New World Renaissance Hotel, Makati City.

IPM CRSP scientists and research staff including the site coordinator served as resource persons/lecturers in the Farmers' Field Schools conducted in seven barangays of Nueva Ecija and Pangasinan Provinces during the 2004 onion season.

Awards

Gergon. E. B. DA Secretary's Award given by the Bureau of Agricultural Research, Dept. of Agriculture, Diliman, Quezon City on Oct 9, 2003.

Gergon, E. B. Outstanding Employee Award given by PhilRice, Science City of Muñoz, Nueva Ecija on November 7, 2003.

Technology Transfer Activities

Technology transfer activities for Year 11 were highlighted by the conduct of the farmers field schools (FFS) on IPM in onion production. Seven FFSs were conducted during the 2003-2004 onion cropping season in seven villages of Nueva Ecija and Pangasinan. Some 87 farmers and nine Agricultural Technicians attended and participated in these field schools. Key resource persons in the FFS were the IPM CRSP scientists and project leaders and the IPM CRSP research staff. The FFSs were facilitated and coordinated by the site coordinator, by the IPM CRSP staff and Agricultural Technicians concerned.

The FFS was a very successful educational tool in disseminating the technologies, understanding the technologies and empowering farmers in making decisions. Participants became change agents in the promotion of IPM especially on vegetables.

Training on the use and mass production of VAM and *Trichoderma* was also conducted in six municipalities of Nueva Ecija and Pangasinan. A total of 264 participants were trained from March to April, 2004. Mass production activities are now being undertaken by several farmers. IPM CRSP scientists and project leaders were key resource persons in these trainings. These were coordinated and facilitated by the site coordinator.

Some 263 trainees - farmers, agricultural technicians, municipal agriculturists, municipal government officials (mayors and municipal/city councilors, barangay captains), and high school students were trained on VAM and Trichoderma mass production in six municipalities of Nueva Ecija and Pangasinan.

Before the end of the onion cropping season, two farmers field days were conducted, one in San Francisco, Sto. Domingo with some 300 participants and the other in Bongabon with around 150 participants. Farmers form the other project sites as well as farmers from neighboring villages attended the field days. This activity was conducted to showcase the results of the implemented IPM technologies in the farmer cooperators' fields. During the field days, participants were briefed in the fields after which they were gathered together in a designated assembly area where discussions and open forum were conducted. Scientists from different disciplines were invited as resource persons.

The field days were excellent venues for creating awareness of the existence of IPM technologies among farmers and promotion of these technologies. This activity also answers the attitude of farmers which is"to see is to believe".

The village level integration of IPM technologies project is also one of the best tools for technology transfer. It is participatory in nature so that farmers learn by doing and they are empowered to make management decisions. They have the chance to do their own experimentation and develop the sense of ownership of technologies developed. This approach also contributes to confidence building within and among themselves.

Training materials like the 'Integrated Pest Management in Rice-Vegetable Cropping Systems' Training Manual, Field Guides and Technology Bulletins have been edited, formatted and are now ready for printing.

Publications

Two papers are submitted and accepted for publication in the October 2004 issue of the Philippine Entomologists Journal. These are:

- Arida, G. S., C. C. Ravina, B. S. Punzal, E. G. Rajotte and N. S. Talekar. 2004. Response of the onion plant *Allium cepa* Linn to simulated pest damage. Accepted for publication in the October 2004 issue of the Philippine Entomologist Journal.

- Arida, G. S., B. S. Punzal, C. C. Ravina, V. P. Gapud, E. G. Rajotte and N. S. Talekar. 2004. Monitoring adult populations with sex pheromone traps for effective timing of interventions against defoliators in onion, *Allium cepa* Linn, grown after rice, *Oryza sativa* Linn. Accepted for publication in the October 2004 issue of the Philippine Entomologist Journal.

Training and extension materials that have been edited and formatted and are now ready for printing:

- Training Manual on 'Integrated Pest Management in Rice-Vegetable Cropping Systems'

- Field guide on major insect pests of onion and their management

- Field guide on major diseases of onion and their management

- Technology bulletin on eggplant fruit and shoot borer, and leafhopper management

- Technology bulletin on root knot nematode management

- Technology bulletin on the pink root disease of onion

Drafts Prepared

- Technology bulletin on VAM, its use and mass production

- Technology bulletin on *Trichoderma* sp., its use and mass production

Overview of the Caribbean Site

Year 11 (2003-2004)
Compiled by Dionne Clarke-Harris and Sue Tolin

Description of the Collaborative Program

The workplan 2003-2004 (Year 11) continued the focus on consolidation of developmental work and wider dissemination of developed technologies.

The main collaborating Caribbean and US Institutions of the Caribbean site are Caribbean Agricultural Research and Development Institute (CARDI)- Facilitator, Ministries of Agriculture (St Kitts and Nevis, Trinidad and Tobago, Barbados and St Vincent), Rural Agricultural Development Authority (RADA) in Jamaica, University of the West Indies, Jamaica Exporters Association, The Food Storage and Prevention of Infestation Division (Ministry of Commerce Science and Technology- Jamaica), Pennsylvania State University (PSU), Virginia Polytechnic Institute and State University (VPI&SU), Ohio State University (OSU), University of California at Davis (UC-D), and United States Department of Agriculture U. S. Vegetable Laboratory (USDA-USVL).

IPM CRSP has been a catalyst for a number of initiatives in IPM throughout the region and continues to disseminate information on its activities to other Caribbean researchers through the Caribbean Integrated Pest Management Network (CIPMNET). The work of the IPM CRSP has been presented in numerous regional forums pertaining to IPM in particular and sustainable agriculture in general. Some of the initiatives of the IPM CRSP have stimulated increased interest in the field of IPM resulting in a number of follow-up projects, especially with hot pepper. In the other commodity groups, such as root crops and vegetables, collaborative activities have been ongoing in locations outside of the host country.

IPM Constraints Addressed

Heavy reliance on pesticides in leafy vegetable production is of global concern. Caribbean site activities have focused on drastically reducing pesticide input through rational pesticide use. Achieving this objective would have tremendous impact on consumer safety and reduction of environmental and user hazards. Methods to utilize threshold-based spray application decisions and the use of safer, less persistent, more selective, pesticides have been developed. The effective use of non-chemical management options, such as exclusion, is also being evaluated.

Sweet potato weevils, sweet potato leaf beetles, and the WDS (Wireworm-*Diabrotica*-*Systena*) soil insect complex significantly reduce sweet potato production in Jamaica and the rest of the Caribbean. The incorporation of pest management tactics, such as resistant breeding lines and the use of biorational insecticides, into the present IPM technology will greatly assist sweet potato farmers in the Caribbean in using IPM procedures to produce high quality, competitive products for international markets. Dissemination of IPM technology to farmers in major sweet potato growing areas in the Caribbean is on-going to facilitate the goal of reducing pest damage and improving sweet potato production, thus enabling competitiveness in the global market.

In hot pepper, multiple pest constraints have been identified. Activities this year were designed to establish an IPM model to address the management of viruses, particularly tobacco etch virus (TEV), and how those practices relate to incidence of broad mite and the gall midge complex. Validation of integrated tactics identified to manage the virus complex, and specific identification of viruses in hot pepper, were conducted.

It has been thought that a complex of at least two species of gall midges is responsible for the export quarantine to the U.S.A. We have learned that the biology and ecology of these species differ, and thus may require different management approaches. Cultural control efforts include fruit stripping. This method, plus the harvesting process itself, could result in differential effectiveness of management if one type of plant tissue is segregated. Recent work with molecular probes is now suggesting at least two taxa can be identified from larvae extracted from the fruit pedicel. Successful use of molecular probes would enable IPM studies to occur at a species specific level, and may clarify the taxonomy of this difficult taxa of insects relative to quarantines imposed on export of peppers to the USA.

Monitoring and surveillance of the gall midge, which is viewed as the critical component to addressing the USA's quarantine issues with this hot pepper pest, continues to be a major emphasis. At the field level, sampling of pepper plots across the island was unsuccessful in identifying pest-free areas or periods. Data collected suggest, however, the possibility of economically-significant pest-free periods in four growing areas. Pest infestation data were posted on the PestWatch GIS Website, for eventual integration of World-wide Web and GIS for real-time monitoring, communication and dissemination of pest management information. Field extension workers' surveillance capability has been

enhanced through their participation in the project. This will strengthen Jamaica's capacity to meet Global Sanitary and Phytosanitary Systems trading requirements.

Selected Research Accomplishments

Vegetable IPM

- Exclusion and biorational pesticides, using a threshold-based spray application guide, gave significantly improved protection of the crop from insect damage when compared to farmer practice.

- Parallel experimental research activities were initiated in Jamaica and Trinidad to test rational pesticide use strategies against lepidopteran pests of cabbage. Biorational pesticides spinosyn and lufenuron are being tested varying the frequency of application based on established thresholds compared to weekly applications. Participatory Rural Appraisals on cabbage conducted in Trinidad in 2003 were analyzed, and data for PRAs were collected in 2004 from two regions in Jamaica.

- Two cropping seasons of cabbage were completed in both countries and indications are that biorationals applied weekly reduced damage by lepidoptera more than the control however the need to lower the set thresholds is implied as threshold-based applications did not give as good results as the weekly-sprayed plots. A third crop is being monitored as the low pest pressure in the two earlier crops did not allow for conclusive results.

Sweet potato IPM

- Sweet potato entries were evaluated for resistance to soil insect pests in South Carolina. About one- third of 59 entries had either significantly higher percentages of clean roots or significantly lower WDS ratings than the susceptible check cultivar 'Beauregard'. Significant resistance to white grubs, flea beetles, and sweet potato weevils was also observed. These results demonstrate high levels of insect resistance throughout this germplasm base.

- Overall, less insect damage was observed on sweet potatoes grown in a killed cover crop (crimson clover) minimum tillage system than in conventionally tilled plots. Additionally, weeds had a significantly greater detrimental effect on yields in the conventionally tilled plots than in the killed cover crop plots.

- Floral-lure baited traps were very efficient for monitoring spotted cucumber beetles, *Diabrotica undecimpunctata*, which is part of the WDS pest complex. These traps were somewhat less effective for monitoring D. balteata, another WDS pest that is widely distributed in the Caribbean.

- Imidacloprid and a neem formulation gave the highest mortality of adult sweet potato leaf beetles and have potential for inclusion in the management of the beetle.

- Four hundred specimens of *Cylas formicarius*, the sweet potato weevil (SPW), were collected in March 2004 by RADA agricultural extension officers from seven different sweet potato-growing areas in six parishes (St Catherine, Clarendon, St Elizabeth, St Ann, St Andrew and St Thomas) of Jamaica. The samples were sent to the Genome Research laboratory, North Carolina State University, USA for DNA extraction and molecular characterization, in the study to compare the genetic diversity of different populations of this major pest.

IPM for Broad Mite on Hot Pepper

- Additional sampling confirmed that larger populations of broad mites were recovered in samples taken from fields with high pesticide use, compared with those from fields with no pesticide usage. Conversely, populations of predators were higher in fields with no pesticide usage than in fields with high pesticide usage.

- Broad mites were found mainly on lower leaves of the plants whereas predators were distributed more evenly over the plant, with more on the upper leaves in both sprayed and unsprayed fields. Distributions on pepper plants suggest that predation at early stages of infestation is most important.

- Abamectin, diafenthurion and hexathiazox provided the best combination of having maximum suppressive effects on broad mite populations and least on its predators, making these chemicals very suitable for use in integrated pest management programs for broad mite on hot peppers.

IPM for Gall Midge of Hot Pepper

- Possible pest-free periods of economically significant duration were identified in four growing areas in Year 10, but elimination of required fumigation of hot peppers from these areas has not occurred.

- Institutional capability of RADA, Jamaica's major agricultural extension agency, has been strengthened in the areas of Extension officer mapping skills and approach to field surveillance. Geographic positioning systems (GPS) hardware has been provided to them under the programme. This should impact positively crucial plant health programmes and enhance agricultural trade potential, while protecting local agriculture, human health and environmental well-being.

- The Web GIS programme PestWatch has been launched on the RADA website and over two hundred entries posted. The software is now working properly as the software developer, B. Miller (PSU), has rectified previous problems.

- Two Caribbean Scientists benefited from short-term training opportunities in the USA to develop their knowledge-base in the field of biotechnology, one of the emphases of IPM CRSP for years ten and eleven. The practical aspect of the training was refreshed in Jamaica during networking activities in Jamaica.

- Work has begun in the development of molecular probes for gall midges on Jamaican hot peppers. Results have suggested that a complex of two gall midge species or sub-species may be present in the fruit pedicel. This pioneer effort, if successful, will have major impact on Jamaican agriculture as well as applicability to similar pest problems where rapid pest diagnosis is needed .

IPM for Viruses of Hot Pepper

- A field experiment to validate management practices to delay or prevent infection of Scotch Bonnet pepper with TEV was conducted at CARDI, using combinations of mulch and stylet oil sprays. Plots were monitored weekly by serologically testing for virus. Reflective mulch was most effective in delaying infection, but exhibited some plant damage.

- Techniques were developed to isolate viral RNA from infected peppers, which was then reverse transcribed, amplified by polymerase chain reaction (PCR) by using specifically designed primers, and sequences obtained. Preliminary comparisons confirm the virus in Jamaican hot peppers is closely related, but not identical, to previously sequenced TEV.

Weed Management

- A Jamaican student being funded by IPM CRSP Caribbean Site to pursue a PhD program at the University of the West Indies-Mona, is scheduled to complete the programme in 2005. The project title is "Solarization and mulching as weed management strategies for organic agriculture". Below are some highlights of her research.

- Total weed growth (as percentage cover and density) in plots mulched with shredded *Gliricidia sepium* (Quick stick), *Mucuna* sp. and *Panicum maximum* (Guinea grass) was significantly lower than the un-mulched control at both five and seven weeks after mulching. Guinea grass and *Mucuna* showed the lowest weed growth. The amount of material appeared to determine the success of weed control, since a thinner mulch (of Neem) reduced weed growth less than the other mulches.

- Weed assessments carried out in plots or Scotch Bonnet pepper with reflective plastic and straw mulches (used in aphid management studies) conducted at the CARDI Mona DTC revealed that weed growth (total weed biomass) was significantly reduced in plots with reflective plastic and grass, when compared with plots sprayed with herbicide at 6 and 9 weeks after mulching. The most abundant weeds in the control, *Portulaca oleracea* (a dicotyledonous weed) and *Leptochloa filiformis* (a grass weed), were both significantly reduced by the two mulches.

- Preliminary results of a pot trial to determine the effect of mulching and solarization on the total non-structural carbohydrate content and development of Johnson grass (*Sorghum halepense*) rhizomes have indicated that grass mulching enhanced Johnson grass rhizome and shoot growth, while solarization did not affect rhizome mass but inhibited shoot production. Tests on the total non-structural carbohydrate content of the rhizomes are ongoing.

- A field trial was set up to determine the effects of possible constraints within the soil environment (temperature, moisture, pH, nitrogen availability) and seed recruitment on the establishment of the weed community in mulched and solarized treatments.

Technology Transfer

- The dissemination of information on management of pests of vegetable amaranth (callaloo) using exclusion and biorational pesticides, is now being carried out on a wider scale as the national extension service, RADA, has been convinced of the value of the approaches for farmers. The Jamaica Organic Agriculture Movement (JOAM) has approved the exclusion method as an acceptable option for organic growers. JOAM was given technical assistance towards the establishment of a demonstration plot on the grounds of Kings House, whose resident, the Governor General of Jamaica, has an avid interest in organic farming and has endorsed the promotion of alternative technologies.

- 4-6 June 2004, the environmentally friendly technologies and activities conducted by CARDI/ IPMCRSP were displayed at the National Green Expo held at the National Arena. The display included posters and live demonstrations presented to an audience of patrons from a wide cross section of the society. This event is particularly strategic for reaching the youth in schools across the island.

- 31 July-2 August 2004, all technologies and activities conducted by CARDI/ IPMCRSP were displayed to over 1,100 patrons at the Annual Denbigh Agricultural Show. The display included posters and demonstrations.

- RADA officers across Jamaica conducted 12 formal sweet-potato IPM farmer-training sessions involving 196 farmers, under a Plant Health contract for the Interamerican Development Bank (IDB)/government of Jamaica-funded Agricultural Support Services Project (ASSP). This utilizes IPM-CRSP generated technology. Several informal sessions were also conducted.

- The first Regional workshop on Geographic Information Systems for Pest Surveillance held in 26-29 April 2004, in Trinidad & Tobago, transferred the technology of GIS to pest management and quarantine officials in seven Caribbean nations.

Networking Activities

- Drs Jackson and Bohac continue to serve as members of the Sweet potato Crop Germplasm Committee of USDA.

- 2003. Phillip Chung negotiated linkage of CIPMNet e-group to PestNet south-Asian pest information network, PestNet@yahoogroups.com.

- 15 – 19 December 2003. KM Dalip visited St Kitts and St Vincent to view ongoing sweet potato trials, visit some of the farms involved in sweet potato weevil trapping survey, review status of workplan for Year 11 and advise on data collection and modifications to experiments to be conducted.

- 23-25 January 2004, Dr. Jackson and J. Bohac attended the National Sweet potato Collaborators Meeting, Baton Rouge, Louisiana.

- 22-26 March 2004. IPM CRSP Collaborators, Drs Shelby Fleischer, Pennsylvania State University, Sue Tolin, IPM CRSP Site Chair, Virginia Tech (VT), Janet Momsen, University of California-Davis, and D. Michael Jackson USDA Vegetable Laboratory, Charleston South Carolina, and Lilory McComie from Ministry of Agriculture Land and Marine (MALMAR), Trinidad & Tobago, visited CARDI Jamaica Unit for the annual review meeting of the IPM CRSP (US and local collaborators, including D. Clarke-Harris, K. Dalip and P. Chung) to assess progress of the current (Year 11) workplan and discuss writing and compilation of final report. During the week, the Annual Planning and Review Meeting of the Caribbean Site was held (24-25 March 2004). The IPM CRSP collaborators also met with stakeholders and relevant persons from USAID Local Mission, UWI, Ministry of Agriculture Research Arm, Rural Agricultural Development Authority, and the Hot Pepper Task Force.

- 26 – 29 April, 2004. S. Tolin and S. Fleischer met with V. Lopez of CABI in Port-of-Spain, Trinidad, to discuss ways to synergize IPM efforts, with an emphasis on CABI progress with farmer field schools, and biological control with both arthropods and microbials.

- 26 – 29 April, 2004. S. Tolin and S. Fleischer met with Dr. Brathwaite, Chair, and other faculty of the Department of Food Technology, University of West Indies, St. Augustine, Trinidad, to discuss ways to strengthen MSc programs in Plant Protection and Biotechnology.

- 26 – 29 April, 2004. S. Tolin and S. Fleischer met with C. Prasad, Ministry of Agriculture in Trinidad & Tobago, to discuss current issues in the Caribbean relative to Biotechnology Policy and Research, and the use of GIS in IPM programs.

- 9 – 13 June 2004. Clive Edwards visited Jamaica to review progress of the Year 11 workplan, particularly the hot pepper activities. Dr. Edwards also met and held discussions with relevant persons from UWI, University of Technology, and Ministry of Agriculture Research division.

- 18 June 2004, Phillip Chung launched an electronic discussion group for technical support and on-going communication in GIS, CIPMNetGIS@yahoogroups.com, among participants of the first Caribbean Regional Workshop on Geographic Information Systems for Pest Surveillance.

- 1 – 4 August, 2004. D. Clarke-Harris, Site Coordinator, visited Pennsylvania State University to meet with USA collaborators, get a first-hand view of relevant research activities, and presented a seminar entitled “Highlights of Agricultural Research: A CARDI perspective” to faculty and staff. She also explored possible areas for future collaboration through networking with the High-Tunnel Research facility and the cocoa breeding program, and. reviewed on-going efforts at developments of molecular probes for gall midges and the weed science training program.

- August 5-6, 2004. D. Clarke-Harris, Sue Tolin, S. Fleischer, Clive Edwards and Phillip Chung participated in the meeting, “Globalizing IPM through Participatory Research: Lessons from the IPM CRSP”, Washington DC. Two thematic talks

were presented by Caribbean Site collaborators: (1) Web Deployment with GIS for IPM by S. Fleisher, and (2) Complementarities between IPM and Biotech by S. Tolin.

- 15 – 20 August 2004. IPM CRSP Collaborator Dr. Liwang Cui, Penn State University, visited Jamaica. Drs. Cui and Dalip collected gall midge-infested hot pepper samples from St Mary and later extracted the gall midge samples for DNA. Dr. Cui also held discussions with J. Goldsmith and K.M. Dalip on determination of gall midge species using external morphology and molecular biology techniques.

Training

- A Ph.D. student program in Weed Science at the University of West Indies (UWI), Mona campus, was begun and coordinated with Weed Science seminars to be merged into the IPM resident education program at UWI. D. Mortensen will serve on the Ph.D. program and deliver the seminars in coordination with J. Cohen and D. Robinson, faculty at UWI, Mona.

- S. Fleischer served as external reviewer for two UWI theses: (1) the biology, ecology and control of the yam weevil, and (2) cultural and biorational methods of control of diamondback moth.

- 26-29 April 2004. The Caribbean Regional Workshop on Geographic Information Systems for Pest Surveillance was held at the University of West Indies, St. Augustine campus, Trinidad & Tobago. It was organized and conducted by P. Chung, A. Roberts, B. Miller, S. Fleischer, J. Opadeyi, S. Tolin. The fourteen participants included personnel from the Ministries of Agriculture and Plant Protection Officers from Trinidad, Dominica, St. Lucia, Antigua, Jamaica, St. Vincent, and Grenada. This workshop also advanced the integration of the Centre for Geospatial Studies of the Department of Engineering in UWI with IPM programs and the mission of PROCICARIBE, the Caribbean Agricultural Science and Technology Network System.

- 1 June – 31 August 2004. S. Tolin hosted W. McLaughlin, UWI Biochemistry Department Professor, at the plant virology laboratory at Virginia Tech, where he received training in RNA virus isolation and molecular biology, working with TEV, under a Fulbright scholarship.

Regionalization of IPM Technology

Vegetable IPM

- 23 – 24 March 2004, Dr. Lilory McComie of Trinidad and Tobago visited Jamaica to review progress of the parallel research activity in Jamaica in IPM in crucifer production.

- Data collected in Barbados and Trinidad in July 2003 for Participatory Rural Appraisals (PRAs) were analyzed. This information will be used to plan IPM approaches for managing insects pests in cabbage.

- The same survey instrument was used in the summer of 2004 collection of data for PRAs in Jamaica by two MS level students from UWI, Mona.

Sweet potato IPM

- A trapping survey of sweet potato fields in St Vincent is ongoing. Results thus far have confirmed the absence of SPW in that country. The last survey was done more than 10 years ago.

Information Systems

- April 26-29, the Caribbean Integrated Pest Management Network (CIPMNet), on behalf of the Caribbean IPM-CRSP site, coordinated the first Caribbean Regional Workshop on Geographic Information Systems for Pest Surveillance. The University of the West Indies Centre for Geo-spatial Studies, Faculty of Engineering collaborated in the effort. UWI possesses extensive human and institutional capabilities for training and development of GIS in the region. Ten participants from seven countries across the region participated in the 4-day workshop, delivered by US and Jamaican IPM-CRSP collaborating scientists and UWI personnel. A regional GIS e-group launched.

- The hemispheric Inter-American Institute for Cooperation in Agriculture (IICA) expressed keen interest in the workshop, attended sessions and held discussions with collaborators, seeking guidance in planning a similar exercise.

Impacts

Leafy Vegetables

- Addressing the problem of over-reliance on pesticides in leafy vegetables will have far reaching effects on consumers, users of pesticides, and on environmental quality. Rational pesticide usage alone has demonstrated the potential to reduce pesticide inputs by more than 50%. This, coupled with the use of less persistent pesticides, is a significant impact. Addressing the cosmopolitan problem of heavy

pesticide use against diamond back-moth is strategic and will have widespread applicability throughout the Caribbean. The PRAs recently completed in Barbados, Trinidad & Tobago, and underway in Jamaica, will point the way to future approaches.

Sweet potato

- Although sweet potato is an important traditional crop for many countries in the Caribbean, both as an export product and as a staple in the local diet, several similarities and differences exist among the islands of the Region. However, the availability of suitable land is a constraint and new alternative tillage systems are needed in the Caribbean to combat soil erosion and weed problems. The benefits of a killed-cover crop system, with respect to weed growth and grub damage to tubers, were demonstrated in Year 10. It is being repeated in Jamaica and is also being compared to plastic mulches. The results of this trial will also be of interest to the growing organic farming sub-sector.

- The development and eventual incorporation of new monitoring and management techniques for the major sweet potato pests, together with the identification of sweet potato varieties showing tolerance to the major pests, and the potential inclusion of botanical insecticides, biorationals, and pheromones, will contribute to the effectiveness and success of an IPM programme for sweet potato.

- The use of sweet-potato weevil pheromone lures under an IPM programme continues to gain popularity among farmers in the major growing areas. Supplies are made available by RADA, for purchase, and preliminary discussions were held with a local input supplier to explore the possibility of his being another local source of the pheromone lures.

Hot Pepper

- It was hoped that with the process in place for USDA/APHIS to rescind mandatory fumigation of hot peppers exported to the USA from Jamaica, that the Jamaican farmer/exporter would have the opportunity to maintain a competitive presence in the US marketplace and that pepper exports would return to their previously high levels. However, the Hot Pepper Task Force concluded that the terms and potential penalties of future interceptions were too stringent to accept at this time, since a single interception would cause reversion of the decision. It was estimated that at least two additional years of data on hot pepper gall midge distribution and incidence are needed to identify with confidence areas or periods where gall midge-free infestations exist. Incidence of the pest appears erratic, making it difficult to design management practices. Only when fumigation is lifted would the associated benefits accrue to growers, exporters, distributors and the rural economy.

- Although the gall midge research has not yet impacted gall midge export problems, it has enhanced the technical skills and approach of extension officers involved in field surveillance, particularly for sampling, mapping and implementation of GPS/GIS technology. This has strengthened the institutional capability of RADA to better implement plant health field surveillance programs, now of growing importance to Jamaican agriculture and international trade in fresh produce. The establishment of a traceability system as well as the Web-GIS field monitoring capability, will play a significant role in effective monitoring and surveillance of pests in the future. RADA-Jamaica now has adequate human capacity for managing the PestWatch web-GIS database. This will facilitate a sustainable web-GIS system in Jamaica. The infrastructural capacity of the entire Caribbean region has also been strengthened under the programme, after the workshop held in April.

- The biotechnology projects on gall midge and viruses have both provided results that will impact the hot pepper industry. Gall midge molecular probes have been developed that demonstrate the presence of at least two different species with different ecology and habitats, and will enable IPM studies to occur at a species specific level. Molecular-based data are also being used increasingly for defining the taxonomy, systematics, and host-plant relationships of gall midges; therefore this knowledge will improve taxonomic placement and verification that these pests should be given quarantine status by the USDA.

- The virus biotechnology project has, in a short period of time, developed methodologies and obtained clones and sequences for TEV. This will enable studies on the diversity of the virus in hot pepper in Jamaica and be able to identify strains of virus for pepper breeders to use in selecting resistance naturally or through genetic engineering. Management practices through protecting young pepper seedlings by mulching also has the potential to provide much-needed weed management as well.

Regionalization, Capacity Building, and Information Systems

- Through the processes of networking and information dissemination by training, regional conferences, exhibitions, and CIPMNET, other IPM initiatives throughout the region will benefit from results and experiences of the IPM-CRSP.

- The GIS workshop has had a significant impact in the Caribbean. From it, strategic linkages forged with UWI, IICA and USDA have facilitated synergies among major stakeholders in IPM in the region, offering notable potential benefits. A regional GIS pest surveillance programme for a major fruitfly pest, the West Indian fruitfly, Anastrepha obliqua, has been initiated among participating countries. The USDA/APHIS Caribbean Regional Director has offered support for this effort.

- Interestingly, USDA/APHIS had initiated similar a effort independently, and had planned a workshop for 28 September 28 – 1 October 2004, being organized by IICA. Now, CIPMNet has been asked to assist them, in order to consolidate efforts and build on the outstanding success and achievements of the first, IPM-CRSP-sponsored workshop.

- The Pest Surveillance initiative offers benefits in the emerging issue of Alien Invasive Species, which is of significant trade and ecological concern. The former Commonwealth Agricultural Bureau International, now CABI Bioscience, and the USDA Systematic Entomology laboratory, Maryland, have expressed interest in the effort and working with CIPMNET.

Publications

Presentations

- Lovett, B., J. Goldsmith, S. J. Fleischer, and L. Cui. 2003. Taxonomic placement of gall midges (Cecidomyiidae) affecting hot peppers in Jamaica. National Meeting of the Entomological Society of America. Cincinnati, OH.

- Jackson, D. M. and H. F. Harrison, Jr. 2004. Effects of a killed-cover crop mulch on soil insect pests of sweet potatoes. Paper presented at National Sweet potato Collaborators Meeting, Jan. 23-25, 2004, Baton Rouge, LA.

- Harrison, H. F., Jr. and D. M. Jackson. 2004. Investigation of the potential use of plant breeding approaches to improve weed management in sweet potato. Paper presented at National Sweet potato Collaborators Meeting, Jan. 23-25, 2004, Baton Rouge, LA.

Papers

- Clarke-Harris, D.O. 2003. Rational pesticide use in IPM of pesticide-reliant vegetable crops in the Caribbean. In Proc. Caribbean Food Crops Society Thirty Ninth Annual Meeting 2003, Grenada. XXXIX(2):152-156.

- Goldsmith, J., Edwards, C.A., Martin, R., Clark-Harris, D., Banks, O., Schroeder, M. 2005. A survey of the influence of pesticide use on the incidence of Broad Mite (*Polyphagotarsonemus latus Banks*) and its predators on hot peppers in Jamaica. (Submitted to Phytoparasitica).

- Goldsmith, J., Edwards, C.A., Clarke-Harris, D., James, O. 2005. Effects of biorational pesticides on the incidence of Broad Mite (*Polyphagotarsonemus latus Banks*) and its predators on hot peppers in Jamaica. (Submitted to Phytoparasitica).

- Jackson, D. M., J. Lawrence, K. M. Dalip, P. Chung, D. Clarke Harris, >J. R. Bohac, S. Tolin, C. Edwards, and D. R. Seal. 2003. The sweet potato leaf beetle, *Typophorus nigritus viridicyaneus* (Coleoptera: Chrysomelidae), an emerging pest in Jamaica: Distribution and host plant resistance. Tropical Agriculture (Trinidad) 80: (In Press).

- Clarke-Harris, D., and S. J. Fleischer. 2003. Sequential sampling and biorational chemistries for management of lepidopteran pests of vegetable amaranth in the Caribbean. Journal of Economic Entomology 96: 798-804.

- McDonald, S. A.., S. A. Tolin, and B. Nault. 2004. Effects of timing of TEV infections on growth, yield and quality of 'Scotch Bonnet' pepper (*Capsicum chinense* Jacquin) fruit in Jamaica. Tropical Agriculture (accepted for publication).

- McDonald, S.A., B. Nault, and S. A. Tolin. 2004. Efficacy of Stylet-Oil® in suppressing the of spread of TEV infections in a 'Scotch Bonnet' pepper (*Capsicum chinense* Jacquin) field in Jamaica. Tropical Agriculture (accepted for publication).

Overview of the Eastern European Site in Albania

Site Chair: Doug Pfeiffer (Virginia Tech)
Alternate Site Chair: Charlie Pitts (Penn State University)
Site Coordinator: Josef Tedeschini (Plant Protection Institute)

Description of Collaborative Program

IPM CRSP research activities in Albania in year eleven involved three major types of activities: (1) participatory appraisal and baseline survey to position the CRSP and the host country institutions for the next phase of their IPM program, (2) completion of olive field research, and (3) technology transfer for olive IPM.

The work during year 11 was conducted based on close cooperation between scientists of the Albanian Agricultural Research Institutes and different US Universities. The major Albanian Institutions involved are the Plant Protection Institute (PPI), Durres, Fruit Tree Research Institute (FTRI), Vlora and Agricultural University of Tirana (AUT). Partner US institutions are Virginia Tech, Penn State and University of California.

The year 11 work plan focused on termination of multi-disciplinary projects in olive (1) To determine the optimal time to harvest olives to minimize olive fruit fly infestation and maximize oil yield and quality; (2) To develop a selective attractant-based control system for olive fruit fly, *Bactrocera (Dacus) oleae* (Gmelin). It also focused on a Participatory Appraisal for IPM in Albanian Greenhouse (Tomatoes, Cucumbers), Vineyards and Apple and an Associated Baseline Survey. The third activity was technology transfer through the National Olive IPM Symposium and farmer school.

Planning and collaborative research took place through discussions among host country and US scientists at planning meetings in Albania. The research was based taking in consideration the developing results of last year.

Field research was conducted at the experimental station of FTRI and in two villages. Various laboratory analyses were conducted at FTRI, PPI and AUT, and olive oil analyses were performed at Chemiservice Lab in Italy (accredited by IOOC). The site chair and coordinator maintained frequent communication and all co-PIs maintained communication with their respective collaborators on individual research activities.

The host country site coordinator provided frequent oversight of the field research activities together with the other specialists involved in particular research topics.

IPM Constraints Addressed

The key constraints addressed in Albania in year 11 were the need to conclude the IPM solutions to specific pest problems in olive crops. The specific major pest addressed during this year in IPM program was olive fruit fly (B. oleae). The main constraints to olive IPM are addressed by this research:

- Lack of knowledge among olive growers on basic aspects of and beneficial species biology
- Gaps in knowledge in Albania on species composition of additional pests and in beneficial species

Technology Transfer

The workshops for growers and specialists are organized in cooperation with MoAF (Ministry of Agriculture and Food, Directory of Science and Extension Service), AAATA ((Assistance to Albanian Agriculture Trade Association), AOA (Alimentary Oil Association), World Learning Project/USAID, SBCA/USAID (Small Business Credit and Assistance Project), AOAA (Albanian Organic Agriculture Association) and CEFA (Italian NGO). There are some other workshops organized by The Department of Agriculture of Districts (Shkoder, Lezha, Kruja, Durres, Elbasan, Fier, Berat, Saranda, Vlora, Gjirokaster, Peqin).

Several workshops are organized during September 2004: in Elbasan on 14 Sept, (Organized by SBCA/USAID, 25 participants, olive growers and specialists); Saranda on 17 Sept (Organized by Department of Agriculture, about 20 farmers and specialists) ; Shkoder on 20 Sept (organized by MoAF, Directory of Extension Service, about 25 Farmers extension service officers), Vlore 21-22 Sept (organized by MoAF, FTRI Vlora with specialists of horticulture) and the next one will be organized on Lezha, 24 Sept (organized by MoAF, Directory of Extension Service). At the end of September 04 we are finished the Manual, IPM in Olive that will be send for publication.

Selected Research accomplishments

Descriptions of research progress and results are provided in the individual activity reports but the following are the key results obtained in the Albanian site:

Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality

For the year 2003 the optimal harvest time for the Kalinjoti cultivar as shown from the results obtained may be the first decade of November. During this period the olive oil content in the fruits was not different from olives harvested later. Due to the moderate level of olive fruit fly infestation the early harvest of olive is recommended to escape from fruit fly infestation.

The olive oil analysis of cv Kalinjoti performed at Chemiservice laboratory (an accredited lab by IOOC in Italy) indicated that it is possible to produce extra virgin oil using early harvesting. The olive oil produced on October 15 and November 1 had lower levels of free acidity compared with the olive oil produced on November 15, which fell in the virgin category. The olive fruit fly infestation during early harvest period (15 October-1 November) was lower compared with the other treatments (15 November).

Pheromone-Based IPM in Olive and Effects on Non-Target Species

The "Attract and Kill" method, an improved form of mass trapping was evaluated until the end of November 2003 in several olive groves to control olive fruit fly Bactrocera oleae (Gmelin). This method was compared with chemical applications that constitute the standard control method today for the control of this pest. Both pest population density and fruit infestation levels, main parameters used for the evaluation of the two methods were considerably lower during the season in the orchards protected by mass-trapping and chemical control compared to the untreated control. No complementary measures were required in the mass-trapping orchards for acceptable crop protection. In general, the results indicated that using one killing device/tree baited with ammonium bicarbonate and pheromone (2 treatments, June and September) has the potential to keep the level of fruit infestation similar to that obtained in the control orchards treated at least twice with the insecticide. Good results were obtained also using the Eco-traps, one every other tree, during September, thus reducing the cost.

After a large-scale application of mass-trapping technique, the farmers were highly impressed and showed keen interest to adopt the technology in the main region of olive growing.

Mutuality of Benefits of the Research

Fruit specialists in Albania receive training in modern techniques of biological control, fruit production and the implementation of IPM in a free market context. IPM practices not disruptive to ecological systems or human welfare will be developed allowing Albanian olive products to be competitive in an international market. The pest problems assessed in our studies are common and widespread in Europe and in all the regions of olive cultivation. IPM approaches to manage these problems have broad applicability especially in the neighbouring countries. Benefits to U.S. relates to observation of IPM system in perennial cropping systems under a regime of low pesticide availability. American commodities are facing loss of key pesticide groups and specialists will benefit from working in the Albanian system especially in light of recent introduction of the olive fruit fly into U.S.

Institution Building

Funds provided by the IPM CRSP Albania supported the research program of the three institutions by supporting technical staff, travel to research sites and providing supplies for experimental purposes.

Scientists travel

D. Pfeiffer travelled to Albania to organize National Olive IPM Symposium on 17 June 2004.

J. Tedeschini and H. Paçe travelled to Washington D.C. to participate in the IPM Workshop "Globalizing IPM through Participatory Research. Lessons from the IPM CRSP" on 5-6 August 2004.

D. Pfeiffer, C. Pitts, K. Moore and T. Bratsch travelled to Albania during 9-19 August 2004 to organize and participate in a participatory appraisal and baseline survey on greenhouse vegetables, vineyards and apple orchards.

Human Resource Development

Two IPM CRSP researchers are using the results of IPM research activities to complete their studies obtaining the Degree "Doctor of Science" in Agricultural University of Tirana. (Mendim Baçaj and Bardhosh Ferraj, FTRI).

Networking Activities

The IPM CRSP research results have been presented in National Olive IPM Symposium held in Vlora, on 17 June 2004. During the Symposium the following topics were presented:

1. Project presentation IPM CRSP—Albania
D. Pfeiffer, J. Tedeschini

2. Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems
J. Tedeschini, H. Paçe, B. Stamo, V. Jovani, B. Huqi, Sh. Shahini, R.Uka, M.Hasani, M. Baçaj, C.Pitts, D. Pfeiffer, L. Ferguson, B. Teviotdale, M. McGiffen

-Monitoring of key olive pests and their natural enemies (olive fruit fly, olive moth and black scale).
-Monitoring of secondary pests (olive mites, olive psyllid, etc.)
-Monitoring olive nematodes.
-Monitoring of olive diseases.
-Monitoring of weeds.

3. Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality

J. Tedeschini, F. Thomaj, Dh. Panajoti, B. Ferraj, M Baçaj, M. Bregasi, C. Pitts, D. Pfeiffer, L. Ferguson.

4. Organic Methods of Vegetation Management and Olive Insect Control

J. Tedeschini, B. Stamo, B. Huqi, H. Paçe, Sh. Shahini, H. Ismaili, Dh. Panajoti, M. Baçaj, M. McGiffen, L. Ferguson.

-Organic methods of soil management and their effect in olive production.
-Organic methods of weed management in olive orchards.
-Organic methods of olive pest management.

4. Effect of Pruning on Olive Production. The incidence of Olive Knot and Timing of Copper Sprays to Control Leaf Spot and Olive Knot

J. Tedeschini, B. Stamo, H. Paçe, R. Uka, M. Hasani, Z. Veshi, M. Baçaj, D. Pfeiffer, L. Ferguson, B. Teviotdale.

-Effect of pruning on olive production and the improvement of spray penetration.
-Timing of Copper Sprays to Control Leaf Spot and Olive Knot.

5. Application of "Attract and Kill" method (using EcoTraps) f or the olive fruit fly control.

J. Tedeschini, R. Uka, M. Baçaj, D. Pfeiffer.

6. Economic impacts of IPM CRSP research on olive pest management in Albania

L. Daku, G. Norton, D. Taylor, D. Pfeiffer, J. Tedeschini

The IPM Symposium was attended by 90 participants from USAID/Mission in Tirana, MoAF, AUT, International Organizations, specialists from MAI-Bari, ITALY, Extension service officers from the main region of olive cultivation, olive growers, etc. This activity was presented on National and Local televisions and in an Agricultural Journal ("Bujqesia Shqipetare").

To present appropriate IPM technologies and concepts to Albanian olive growers, 5 regional workshops were conducted in cooperation with MoAF (Directory of Science and Extension Service) on 16 and 20 February 12 and 25 March and on 29 July 2004. Six presentations were prepared from our project and participants (inspectors, Albanian olive growers, farm-advisers) received materials and leaflets from our colleagues. About 165 participants from the main region of olive cultivation (Vlora, Peqin, Elbasan, Gramsh, Durrës, Kruje, Fier, Lushnje, Berat and Tirane) attended and the techniques of control of the main pests, diseases and weeds were presented. The development of pests and diseases during the growing season was shown.

The results obtained under this project were presented at three regional workshops held on 16 October 2003 and 4 March 2004 in Elbasan district and on 23 April 2004 in Maminas, Durrës (organized by SBCA/USAID funded Project), attended by 80 specialists, researchers, extension officers and farmers.

Efforts were made to share the results and impacts with researchers and olive growers during the Agro Business Fair organized by KASH and ABMC on 21-24 May 2004. Four posters and about 400 leaflets were distributed also during Agricultural Books Fair organized on 8-11. 12. 2003.

During June 2003, the results of IPM in olive were presented for students in Agriculture University of Tirana (November 2003)

Three other workshops will be organised during September 04.

PA Activity

A second participatory appraisal was carried out from 11-18 August 2004. The purpose of this PA was to allow Albanian and American scientists to prioritise research needs in two cropping systems: greenhouse tomato and cucumber, and vineyard and apple orchards. Farm visits were made on 12 Aug (Tirana-Durrës), 13 Aug (Lushnje-Fier), 14 Aug (Berat-Vlora), and 15-16 Aug (Korce). On each day, four groups each visited 2-6 farms. Americans on the PA were Doug Pfeiffer, Tony Bratsch and Keith Moore (Virginia Tech) and Charlie Pitts (Penn State). Albanian scientists were Josef Tedeschini, Brunhilda Stamo, Harallamb Paçe, Ejup Cota, Shpend Shahini and Jordan Mercuri (PPI), Rexhep Uka, Myzejen Hasani, and Magdalena Bregasi (AUT), and Dhimiter Panajoti and Hipokrat Fiku (FTRI), plus representatives from a new institute to our program, Xhevat Shima, Davida Pertena, Elisabeta Susaj and Ylli Subashi (Vegetable and Potato Research Institute). Major needs in information transfer were found, including pest biology and pesticide safety. A working paper is in preparation, which will be posted on the IPM CRSP web site, with more detailed information on the PA.

Presentation of Phase II IPM CRSP Achievements to USAID

In lieu of the annual Technical Committee (TC) Meeting for Year 11, the TC conducted an IPM CRSP Symposium in Washington, D.C., "Globalizing IPM Through Participatory Research: Lessons from the IPM CRSP" (5-6 August 2004). Dr. S. K. De Datta (Principal Investigator, IPM CRSP, Virginia Tech) opened the sessions introducing Bobby Moser (Dean, College of Agriculture, The Ohio State University and Chair, IPM CRSP Board of Directors) for a key note address on the "Importance of Collaborative International IPM Research". Program Director E. A. "Short" Heinrichs followed with a program overview for the two-day meeting.

The first program session addressed issues concerning Collaborative Management and Participatory IPM Research with presentations by S. K. De Datta, "Collaborative management and Structure of the IPM CRSP", Ed Rajotte (Pennsylvania State University), "Participatory IPM Process: Experiment and Experience", and Emmy Simmons (Assistant Administrator/EGAT), "USAID's New Vision for Agriculture: the Role of the CRSPs and the U.S. University Community."

The topic of IPM Diffusion and Impacts was presented by Sally Miller (The Ohio State University) who highlighted the scientific advances made by the IPM CRSP. S. Mohankumar, (Tamil Nadu Agricultural University) specifically addressed the regionalization of biotechnology research in South and Southeast Asia. Short Heinrichs discussed the strategies used by the IPM CRSP to guide behavioral change from the village to global IPM communities. The session ended with George Norton (TC Chair, IPM CRSP, Virginia Tech) summarizing the local, national, and global impacts made by the IPM CRSP.

During the afternoon sessions, the lessons learned by the IPM CRSP in promoting IPM practices were shared. In the first of these sessions, Site Chairs Mark Erbaugh (East Africa, The Ohio State University), Jeffrey Alwang (Latin America, Virginia Tech), Sally Miller (Asia, Ohio State

University), Sue Tolin (Caribbean, Virginia Tech), and Doug Pfeiffer (Eastern Europe, Virginia Tech) characterized site specific lessons describing what worked, what didn't and how future research progress could be achieved. The next session brought the discussion of lessons learned to the global level. Steve Weller (Purdue University) focused attention on markets and trade, highlighting the role of IPM in addressing key issues in pre-inspection programs for non-traditional agricultural export crops. Shelby Fleischer (Pennsylvania State University) introduced recent advances in web-based applications of GIS for IPM. George Norton presented the core lessons learned for impact assessment methods. Keith Moore (Virginia Tech) drew attention to the growing IPM network and how distant stakeholders could influence farm level practices. Colette Harris (Virginia Tech) evaluated key methodologies for incorporating gender issues into IPM practices at various levels of the system. Sue Tolin (Virginia Tech) demonstrated the complementarities between IPM and biotechnology.

The following morning was opened with a session highlighting approaches and institutions for fostering IPM diffusion. Site Coordinators A.N.M. Rezaul Karim (Bangladesh), Sam Kyamanywa (Uganda), Carmen Suarez (Ecuador), Dionne Clarke-Harris (Caribbean), Aurora Baltazar (Philippines), Guillermo Sanchez (Guatemala), Kadiatou Touré Gamby (Mali), and Josef Tedeschini (Albania) introduced the successes and lessons learned at the country level in the promotion and dissemination of IPM practices.

The concluding address was delivered by Dr. Michael Irwin (External Technical Committee Member, IPM CRSP, University of Illinois) who provided a vision for the future of IPM research and the challenges it must face. The TC Meeting was wrapped up with a discussion led by S. K. De Datta and Short Heinrichs thanking all the Co-PIs and our USAID supporters for their contributions to the successful completion of eleven years of IPM CRSP activities. Dr. Bob Hedlund, IPM CRSP CTO, USAID, congratulated the Management Entity and the scientists of the partner institutions for their contributions toward achieving the goals and objectives of the IPM CRSP Program. Dr. De Datta closed the meeting at mid-day.

TRIP REPORTS, YEAR 11

Trip reports from Year 11 of the IPM CRSP totaled as follows:

Albania: 1; Bangladesh: 2; Costa Rica: 1; El Salvador: 1; Eritrea: 1; Guatemala: 1; Honduras: 2; India: 2; Jamaica: 1; Mali: 2; Nicaragua: 1; Philippines: 3; Uganda: 1.

These reports are all posted on the IPM CRSP web site:

http://www.ag.vt.edu/ipmcrsp/index.asp

Publications, Presentations and Other Products of the IPM CRSP
Cumulative Compilation through September 24, 2004

Category	*General /Global*	*Albania*	*Bangladesh*	*Ecuador*	*Guatemala*	*Jamaica*	*Mali*	*Philippines*	*Uganda*	*Total*
Articles Published in Refereed Publications	2	0	2	8	12	26	7	16	28	101
Books/Book Chapters	16	0	0	1	2	0	0	1	0	20
Theses and Dissertations	0	0	3	17	9	4	5	5	16	59
IPM CRSP Annual Reports and Highlights	18	0	0	0	0	0	0	0	0	18
Extension Publications (large)	0	0	3	12	5	11	4	4	3	42
Conference Proceedings	20	1	0	8	69	20	14	40	43	215
IPM CRSP Working Papers	2	2	2	1	6	0	3	7	3	26
World Wide Web Sites and Documents	2	1	0	0	0	3	0	0	0	6
Germplasm Releases	0	0	0	0	0	7	0	0	0	7
Workshops, Courses, Field Schools and Field Days	0	3	2	31	28	21	10	10	23	128
Papers/Seminars Presented	0	11	6	49	103	78	35	52	137	471
Electronic Presentations	0	0	0	0	0	4	0	0	3	7
Posters	1	0	6	0	6	30	5	55	16	119
Fact Sheets (small ext. pubs.)	0	1	0	1	0	4	2	18	7	33
Newsletters	23	0	0	0	0	2	1	2	4	32
Videotapes	0	0	0	1	0	1	7	1	0	10
Magazine and Newspaper Articles	0	0	0	2	1	1	1	2	4	11
Reports	51	29	78	88	199	208	139	171	142	1105
Abstracts	0	0	0	0	2	14	3	2	8	29
Bibliographic Databases and Miscellaneous	0	0	0	0	0	0	1	6	0	7
TOTAL	135	48	102	220	443	434	237	392	437	2448