IPM CRSP ANNUAL HIGHLIGHTS FOR YEAR 7 (1999 - 2000)

Funded by USAID under Grant No. LAG-G-00-93-00053-00

Virginia Tech

VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Office of International Research and Development
Outreach Division, Office of the University Provost
1060 Litton Reaves Hall
Blacksburg, Virginia, 24061-0334

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IPM CRSP US Institutions

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

Host Country Institutions

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

International Centers

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

Private Sector

The Kroger Company
PICO
Caito Foods

NGOs/PVOs

CLADES; GEXPRONT,Guatemala; CARE,Bangladesh

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INTRODUCTION

The purpose of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) is to develop and implement a replicable approach to IPM that will help 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 reduce crop losses, increase farmer income, reduce pesticide use, reduce pesticide residues on 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.

Working towards this goal the IPM CRSP follows 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 collaborations between scientists of the participating host countries and US institutions. The participating host country sites of the CRSP during Year 7 included Albania, Bangladesh, Ecuador, Guatemala, Honduras, Jamaica, Mali, The Philippines, and Uganda. Among the active partner US institutions are: University of Georgia, Lincoln University, Montana State University, Ohio State University, Penn State University, Purdue University, U.C., Davis and Riverside, University of Maryland - Eastern Shore, North Carolina A&T University, Fort Valley State University, USDA, and Virginia Tech (VT) with VT as the lead and the Management Entity (ME) institution.

This report highlights the activities of the CRSP during Year 7 of its operation. The main part of the report is a presentation of the CRSP's activities by its main regions: Africa, Latin America, the Caribbean, Asia, and Eastern Europe. For each active site in a region this document gives a description of the collaborative program, IPM constraints addressed, selected research accomplishments, progress made in training and institution building, and networking activities. The remaining sections of the report cover several major activities of the CRSP such as the Board of Directors Meeting, Technical Committee Meetings, External Evaluation Panel Reviews, Trip Reports, and Technical Assistance. Details on each of these topics and other related items can be found in the institutional reports of the Year 7 Annual Report of the IPM CRSP.

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 7 were:

Africa Site in Mali: Keith Moore, Virginia Tech (Site Chair), John Caldwell, Virginia

Tech (outgoing Site Chair, resigned during the year), Kadiatou Touré Gamby, IER (Site Research Coordinator), Bouréma Dembélé, IER (Site Administrative Coordinator).

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

Latin America Site in Ecuador: Jeff Alwang, Virginia Tech (Site Chair); Roger Williams, Ohio State University (outgoing Site Chair, resigned during the year); Patricio Gallegos, INIAP (Sierra Site Coordinator); Carmen Suárez, INIAP (Littoral Site Coordinator).

Latin America Site in Guatemala: Glenn Sullivan, Purdue University (Site Chair), Guillermo Sanchez, Universidad de Valle de Guatemala (Site Coordinator)

Caribbean Site in Jamaica: Sue Tolin, Virginia Tech (Site Chair); Dionne Clarke-Harris, CARDI (Site Coordinator); Janet Lawrence, CARDI (outgoing Site Coordinator, resigned during the year)

Asia Site in Phillippines: Sally Miller, Ohio State University (Site Chair); Ronaldo T. Alberto, PhilRice (Site Coordinator)

Asia Site in Bangladesh: George Norton, Virginia Tech (Site Chair), Rezaul Karim, IRRI Dhaka / BARI (Site Coordinator)

Eastern Europe Site in Albania: Charlie Pitts, Penn State University (Site Chair), Doug Pfeiffer, Virginia Tech (Alternate Site Chair); Josef Tedeschini, Plant Protection Institute, Durres (Site Coordinator)

In the Management Entity the following contributed to the report:

S.K. DeDatta, Principal Investigator, IPM CRSP and Director of the Office of International Research and Development (OIRD), Virginia Tech.

Brhane Gebrekidan, Program Director, IPM CRSP, Virginia Tech.

Greg Luther, Assistant Program Director, IPM CRSP, Virginia Tech.

AFRICA REGION

Mali

Keith M. Moore (Interim Site Chair), Office of International Research and Development, Virginia Tech; Bouréma Dembélé (Site Administrative Coordinator), Institut d'Economie Rurale, Mali; Kadiatou Touré Gamby (Site Research Coordinator), Centre Régionale de Recherche Agricole de Sotuba, Institut d'Economie Rurale, Mali

Description of the Collaborative Program

The IPM CRSP research program of the Africa Site in Mali is carried out through collaboration of a multi-disciplinary team of scientists based at five U.S. and four 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 *Central Veterinary Laboratory (LCV)*, and the *Université de Mali*. The 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, 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 Millet and Legumes Entomology based in Sotuba, ensures the scientific coordination of the project, and Dr. Bouréma Dembélé, Scientific Coordinator for the Scientific Division of the 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. The *University of Mali* provides training for Master's students through its *Institut Supérieur de la Formation et de la Recherche Appliquée (ISFRA)*.

In the United States, five institutions contribute to the collaborative research program: *Purdue University*, contributing expertise in vegetable IPM (Dr. Rick Foster); the *University of Maryland - Eastern Shore*, contributing expertise in compost and biocontrol agents for seedbed diseases (Dr. Mervalyn Morant); *North Carolina Agricultural and Technical University*, contributing expertise in economics of small-scale producers, including women's horticulture and export markets (Dr. Anthony Yeboah); *Montana State University*, contributing expertise in post-harvest assessment, natural pest control products, and technology transfer (Dr. Florence Dunkel); and *Virginia Tech*, contributing expertise in weed science, pesticide residue analysis, and quality assurance (Dr. James Westwood, Dr. Don Mullins, Jean Cobb and Patricia Hipkins). *Virginia Tech* also provides leadership in the person of the Interim Site Chair (Dr. Keith M. Moore).

In IPM CRSP Year 7, the second year of Phase II, the Mali Site's activities have consisted of participatory on-farm research on IPM

technologies for the management of diseases and insect pests of Mali's two most important peri-urban horticultural export crops (green beans and hibiscus). A third crop has also been introduced this year, tomato. In the first years of Phase II research on horticultural export crop pest management, IPM components are being developed independently to provide the basis for subsequent combination into packages that address different pest problems simultaneously. This research is complemented by on-station research on biological control of the key insect pests of hibiscus, and 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 will focus on the testing of pest management techniques as integrated packages, and the third stage will involve disseminating farmer-tested IPM packages for each horticulture crop in the program.

In addition, these research efforts serve to support the development of a system to reduce pesticide residues on agricultural products through the new *Environmental Quality Laboratory (EQL)* 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 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.

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 production constraints from seeding to harvest. Harvest losses are very high, on the order of 4000 kilograms per hectare, a loss of 160,000 CFA. In addition to the loss in weight, there is also the decline in bean quality caused by insects (such as borers) because the presence of a single damaged pod can 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.

At present the green bean farmers do not have any alternatives to protect their crops other than the use of chemicals of which the origin and mode of appropriate application is unknown to them. Pesticides bought on the local markets are frequently applied up to 4 to 5 times per growing season. The research undertaken in Mali on green beans consists of developing healthy and profitable integrated strategies against insects and diseases.

The impact of pest management tactics on the quality of horticultural crops grown for domestic consumption and export has been difficult to assess. In order to rectify this situation, the *Environmental Quality Laboratory (EQL)* of the *Laboratoire Central Vétérinaire* has been targeted to monitor pesticide residues and thereby provide quality assurance for consumers in Mali and in Europe. This work has involved the development of standardized methods and processes for management decision-making, equipment maintenance, and supplies procurement. Skills in sampling and analysis for pesticide residues are also being developed.

Constraints for two other important peri-urban horticultural crops (tomato and hibiscus) have been diagnosed. For tomatoes, the major constraints identified are diseases attacking the plants and the fruits: viruses, *Fusarium*, soil borne diseases, fungi, and bacterial diseases due to *Pseudomonas*, and insects such as whiteflies (*Aleurodes*), virus transmitting insects, aphids

(particularly in nurseries), and *Heliothis armigera* whose larvae attack the leaves, buds and flowers. Crickets and grasshoppers are also very dangerous in the nurseries, leading to delays in replanting.

Improvements in the production system for hibiscus have been confronted with agronomic problems (fertility and varieties), insects such as *Nisotra*, and diseases due to nematode galls. The latter damage the leaves, leading to late vegetative development and significant petal losses.

The parasitic weed *Striga* remains one of the major constraints to cereal production in sub-Saharan Africa. Research into new approaches for limiting *Striga* damage to sorghum and millet crops in Mali has continued into a second year. This work, initiated in 1999, is testing the hypothesis that small quantities of herbicides absorbed into crop seeds can serve as a deterrent to early parasitic attachments of *Striga*. A critical component of this is the identification of a herbicide that is safe for the crop, yet inhibitory to growth of the parasite.

Selected Research Accomplishments

- Green bean trials were conducted in the irrigated perimeter of Baguinda, at the Sotuba Station, and in three *OHVN* sites (Dialoroba, Sanambelé, and Koren) with farmer associations. The identification of insect species caught on green beans with the insect net principally included thrips and sweetpotato whiteflies (*Bemisia tabaci*). Other insects caught in the traps were not identified. The comparison of the colored traps shows that the yellow traps are effective in the capture of the white flies and the blue traps of the thrips. The red traps capture all the insects but the number captured is not significant.

- For green bean insect management, four types of methods are being tested and compared with the control being no treatment. The highest yields were obtained in the parcels treated with Neem in a soap solution applied once a week associated with the yellow and blue traps. Compared to the control, yields were higher at Koren (29%), Sanambélé (30%), and Dialakoroba (12%), and the irrigated perimeter of Baguineda (49%). These gains are equal to or higher than those obtained in the parcels treated with Decis applied three times associated with Succombi applied once and the soap three times.

- The use of black plastic mulch associated with the incorporation of the cabbage residues and nitrogen fertilization significantly reduced the incidence of the principal green bean diseases allowing for substantial yield increases. The reduction of the number of waterings, also decreased the incidence of green bean diseases.

- An integrated package of technologies for green beans has been established and is expected to be disseminated in the principal producing zones. The IPM package is as follows: Neem applied once per week associated with the yellow and blue traps and the soap applied three times. The yield increases in the IPM parcels compared to farmer practice(the application of Decis three times and of Succomby once) parcels are 12% in Dialakoroba, 41 % in Koren and 34 % in Sanambelé. The farmers were impressed by the quality of the pods and the quantity of the commercially viable pods produced in the IPM parcels.

- Diagnostic examination of weed infestation of horticultural crops began this year. The abundance of the species, *Cyperus rotundus*, shows that the infestations are higher in all the sectors with an average density of 66

shoots per square meter. The invasion of the parcels by this weed is most serious in Banguineda with an average density of 80 shoots per square meter. It is followed by *Euphorbia heterophylia* and *Cynodon dactylon*. Examination of all horticultural parcels demonstrated that 13 weed species had a frequency equal to or higher than 25% in parcels of green beans, of shallots and of lettuce. In addition, the investigations carried out during the study underline the specific problems caused by four weeds which are difficult to control and should be the subject of continued research: *Cyperus rotundus, Cynodon dactylon, Pilea microphylla* and *Commelina benghalensis*.

- Tomato producers are confronted with pest problems involving both insects and diseases. The insects most frequently found in nurseries are the whiteflies *(Aleurodes)*, in fact the punctures made by these insects transmit viruses. Grasshoppers and the aphids are also serious pests, especially in the nurseries. *Heliothis armigera* attack the floral buds and the fruits in their caterpillar stage. The young punctured fruits fall, rot or are otherwise deformed. Diseases also constitute a real problem in the zones of tomato culture. They are present from sowing to harvest. Seed borne diseases are caused by the pathogenic agents: *Botrothis, Pythium* and *Phytophthora*. In certain localities like Kodialan, wilt and bud necrosis constitute major problems and certain farmers have given up growing tomatoes altogether. Other diseases, such as the fungal disease *Alternaria, Cladosporiose,* and fruit rot are also present.

- Covering the nurseries with fabric mosquito netting was very effective in the protection of the young seedlings against the white flies and other pests such as frogs. The number of sprouting seedlings per square meter is twice those without protective covering. During vegetative growth the incidence of the viruses was reduced. The application of hot water on the ground of the nursery associated with the Apron Plus seed treatment allowed for very good sprouting and there was less wilting and fewer viruses at transplanting. The application of the neem extract significantly reduced insect infestations defoliating and puncturing the plants, and reduced damage to the fruit. The Roma varietal parcels treated with Decis or with neem associated with the traps and the parcels of Roma only treated with the neem extract gave the best results.

- The technology package prepared for diffusion among producers consists of: an application of hot water on the soil of the seedbed; protection of the seedbed with mosquito netting; treatment of the seeds with the Apron Plus; treatment of the seedlings with the extract of neem once a week during vegetative growth; use of well decomposed manure; and respect for the proper spacing during transplanting. All of these techniques should be associated with the use of varieties resistant to current viral diseases. When this package is compared with that of the farmers, the infestations and the incidences of pests are reduced by half in IPM parcels and the quality of the production is improved.

- During the inventory of hibiscus pests, fungal diseases due to *Colletotricum hibisci, Rhizoctonia solani* and *Fusarium oxysporum* were identified as well as nematode galls. The inventoried insects are similar to those on other Malvaceae: that is, lepidopterans *Cosmophila flava, Earias biplaga, Helicoverpa armigera, Pectinophora gossipiella*. These insects attack the leaves, flowers and the buds. The hemipterans such as *Dysdercus supersituosis* suck the sap. Among the identified pests, the *Nisotra* spp. flea beetles are the most dangerous. The

adults perforate the leaves, damage the buds, and their larvae attack the roots, creating conditions for fungal contamination.

- A package of IPM technologies including the application of neem extract once a week compared with three applications of Decis and farmers' practice was examined. The IPM method gave a grain yield increase of 8% and an increase of petals of 9 percent compared to the farmer practice. The application of Decis provided a grain yield increase of 34 percent and petals of 47 percent compared to the farmer practice.

- The groundwork has been laid for analyzing pesticide residues in pre-harvest green beans at the *Environmental Quality Laboratory (EQL)* of *LCV*. The lab is now able to analyze green bean samples from IER IPM field trials for deltamethrin results. The data generated will help IPM CRSP scientists assess the impact of pest management tactics on the quality of green beans grown for export. The EQL staff is becoming more proficient and more confident in applying analytical techniques. In addition, the lab is establishing linkages with other West African laboratories with similar mandates for supplies and professional contacts. Ultimately, the lab will monitor pesticide residues in all horticultural crops grown for export as well as those produced for domestic consumption.

- Initial contacts to develop a program for educating growers in the personal and environmental issues involved in safe pesticide handling have been established. This training will improve health and safety in the peri-urban horticultural production region and may reduce pesticide residues on crops. Associated training in Integrated Pest Management (IPM) will result in use of improved pest management practices.

- The 1999 field season results demonstrate that a simple application of 2,4-DB to sorghum seeds reduces the number and dry weight of *Striga* plants attacking the sorghum and millet crops by over 50 percent. Other herbicides appeared to offer some early protection against parasitism as well, but differences were not significant. A similar experiment involving herbicide treatment of millet seed indicated the possibility of herbicide decreasing parasitism in this crop as well, but differences were not statistically significant. These results are currently being confirmed by experiments involving both exact replicates of the previous experiments, and additional trials to further define the efficacy of 2,4-DB using additional herbicide rates and crop varieties.

- The IPM CRSP supported intercropping association of millet-cowpea has been adopted in the Dogon region territory of Tougoumé. It is largely being extended in the Projet de Developpement Rural (PDR) zones of San, but has also been made the object of a three-year study in farmers' fields by the *Directions Regionales* of Ségou, Koulikoro and Mopti and included in a SANREM CRSP package of resource improvement practices in Madiama. The sorghum variety Séguetana CZ1 developed in part with IPM CRSP support has been adopted in the zones of Bla, San, Yangasso, Sirakorola and Kolokani. It is also being distributed in other villages covered by the PDR of San.

Technology Transfer

Since its inception, the IPM CRSP has worked with the *OHVN*, which has the principal objective of ensuring food security and diversification of farmer incomes. The *OHVN*'s zone of intervention is along the Niger River, a region of market-garden production. Through

its Agro Business unit, the *OHVN* ensures the connection between producers and wholesalers, including exporters such as Agro Niger and Mangakilé Company, both exporters of green beans. In the last few years green beans have become one of the principal export crops to Europe and this has allowed many small farmers to engage in export agriculture. In *OHVN* zones, green bean production was 107 tons in 1999 with 95 % destined for export and 5% sold on the local market.

The FAO collaborates with the IPM CRSP 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.

The program carried out through the IPM CRSP focuses on the major thrusts of *IER*'s ten-year strategic plan. The 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.

Collaboration has increased in the dissemination/regionalization of IPM CRSP Mali Site Phase I results. A poster series was developed in collaboration with the *US Peace Corps-Mali* (Ag Sector) and *World Vision-Mali* (Bla Region) as a means of transferring IPM technologies to farmers. Assessment methods for one of the dissemination/regionalization plans has been developed and preliminary testing conducted. It is expected that up to 6,800 small farmers will have access to IPM CRSP research results from the combined Peace Corps and World Vision outreach programs provided with these IPM CRSP training materials. The SANREM CRSP is transferring an adapted version of a striga management practice at its West Africa Site in Mali. Finally, a concept paper for evaluating the economic feasibility of neem oil production was completed in collaboration with the Mali branch of Enterprise Works, International.

Institution Building

The human resource development strategy prepared for the Mali 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* for the training of three Master's degree students in entomology, weed science, and economics/sociology. One of these will continue on to complete a Ph.D. at *Purdue University* and is currently preparing for his TOEFL Examination at the *Institut des Langues* of Mali. A Malian plant pathologist is scheduled to begin a Master's degree program at the *University of Maryland – Eastern Shore*. Two U.S. students will be trained in economics and entomology at *North Carolina A&T* and *Montana State University*, respectively. Mohamed N'diaye, who received his Master's degree in Entomology at *Ohio State* (1999), is now Regional Delegate for the IER Sorghum Program at CRRA/Cinzana and member of the station's IPM team.

Short-term training has been designed as an exchange program. A Malian plant pathologist participated in a short-term training program in *Trichoderma* this year at the *University of Maryland-Eastern Shore* and a Malian weed scientist will be trained in year 8 at *Virginia Tech*. This exchange of short-term training will be balanced by two U.S. students receiving training at *IER*. For the second year in a row, a month long training for two scientists of the *EQL* has been conducted at the Pesticide Residue Laboratory at *Virginia Tech*. An IPM CRSP supported technician and a research

assistant participated in a Farmer Field School training of trainers program at Cinzana for the later training of the other technicians and farmers collaborating in the Farmer Field School Project.

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 to collaborate with *IER* and *LCV* scientists and *OHVN* collaborators on issues ranging from biological control of green bean seedbed diseases (Drs. Morant and Caldwell) and hibiscus insect pests (Drs. Foster and Caldwell), assessment of weeds in peri-urban horticulture (Dr. Westwood), to toxicology laboratory development (Dr. Mullins and Cobb), quality control assurance and pesticide usage and application (Drs. Caldwell, Moore, and Hipkins). On the Malian side, four visits were made to the U.S. Dr. Gamby and Sidibe visited the U.S. for the annual planning meeting and discussions concerning the development of a pesticide safety program for horticultural farmers, and Dr. Traoré and Mrs. Maïga visited the Pesticide Residue Laboratory at *Virginia Tech*.

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.). Additional support for institution building has come from the IPM CRSP in the form of a computer, printer and zip drive for the CRRA/Sotuba research station of *IER* and a computer, printer, Chemstation software, vacuum manifold and nitrogen evaporator for the *EQL* of the *CVL*. The *University of Maryland-Eastern Shore* donated a semplate (petris dishes) to the phytopathology laboratory at Sotuba. 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.

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 based at the *CRRA/Sotuba* research station. The network extends from field agents in the peri-urban horticultural regions encountered frequently in the field (by Pat Hipkins, John Caldwell, Mme Gamby, and Moussa N'diaye) through *OHVN* Director General Cheikne Sidibe who met with Drs. Gamby and Moore. Drs. Mullins and Dem met with Dr. Messaoud Mohammed Lahbib of the *Institut Supérieur de la Formation et de la Recherche Appliquée (ISFRA)* and Dr. Yattara Ianmoud Ibny of the *Microbiology Laboratory* at the *University of Mali.* At the *Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA)*, Dr. Westwood has been responsible for building relations between Dr. Brenda Winkel (Biology, *Virginia Tech*) and Dr. Alhusseini Bretaudeau (*IPR/IFRA*). Dr. Dunkel is developing collaborative relations with the *US Peace Corps-Mali* (Ag Sector) and *World Vision-Mali* (Bla Region) as a means for transferring Phase I IPM CRSP technologies to farmers.

IPM CRSP research results have been presented at the Inter-CRSP Workshop in Bamako, Mali (27-29 January 2000), during the Regional Technical Committee (CTR) meeting at Sotuba (7 May 2000), and at the Regional Users Committee (CRU) meeting at Sotuba (March 2000). From 20 through 30 June 2000, the results were also presented to the IER Program Committee. IPM CRSP results were also presented to 11 NGOs and 4 development

agencies at the PRONAF Workshop (12-13 July 2000).

In the context of the USAID/Bamako-*IER* collaboration, a project has been planned to develop a program extending hibiscus production in the *OHVN* zones. Improvements in the production system for hibiscus have been established as an integral part of the *IER* adaptive research program at the regional level and introduced into the long-term agricultural research strategic plan.

Regional networking is built around several foci. Dr. Caldwell and Pat Hipkins met with Amadou Diarra of the *Institut du Sahel (INSAH)* and Harold van der Valk (*FAO*) to discuss farmer and vendor training in safe pesticide use and IPM technology for horticultural export production. Diarra is the *CILSS* liaison for harmonization of pesticide use and van der Valk is working to assist the *EQL* in developing a network of laboratories in West Africa. Dr. Traoré has initiated contacts with Dr. Larry Vaughan of the USAID/Washington-funded Biopesticide Development Project. Through contacts with the USAID mission-funded *Centre des Agro-Entreprises (CAE)*, the *EQL* is also extending its network as Drs. Caldwell, Mullins, and Traoré have begun collaboration with Dr. Ardjouma Dembélé of *LABECO* in Ivory Coast, particularly in terms of developing improved supply sources for laboratory chemicals.

Uganda

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

Description of 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 Extension Service, participating farmer NGO groups and scientists from IPM CRSP US Institutions. The program in Uganda operates under a Memorandum of Understanding with Makerere University Faculty of Agriculture (MU/FA). The in-country Site Coordinator located at MU/FA is Dr. S. Kyamanywa, Chairman of the Crop Science Department. He is directly linked to NARO through the Deputy Site Coordinator who is appointed by Dr. Joseph Mukiibi, the Director General of NARO. This past year, Dr. JJ Hakiza temporarily replaced Dr. Bigirwa as the Deputy Site Coordinator, while Dr. Bigirwa was on an alternative assignment. The IPM CRSP collaborates with research scientists at three NARO research institutes and one sub-station: Kwanda Agriculture Research Institute (KARI), Namulonge Agricultural and Animal Research Institute (NAARI), Serere Agricultural and Animal Research Institute (SAARI) and the Kalengyere Potato Research sub-station.

During this past year, the IPM CRSP team in Uganda consisted of 5 co-PIs and 4 graduate students from MU/FA, 8 co-PIs from NARO, and 2 extension agents, representing 9 separate disciplines. In addition, there were seven USA-based co-PIs, from 3 universities: The Ohio State University, Virginia Tech, and Fort Valley State University. A Ugandan co-PI and a Ugandan graduate student also participated in

short-term (2 month) training programs in the United States: one at Virginia Tech and one at The Ohio State University Agricultural Research and Development Center. The Site Chair, Dr. Mark Erbaugh, The Ohio State University, coordinates this multi-institutional and disciplinary program. The Site Chair and Coordinator maintain weekly contact and all co-PIs are encouraged to maintain communication with their respective collaborators on individual research activities.

The Site Coordinator administers field research activities with local co-PIs and extension agents. Under a newly reorganized, decentralized Extension System, extension agents report directly to local government officials but rely on NARO and Makerere scientists for assistance in conducting on-farm research and specialized technology transfer activities. Although additional extension agents have been utilized for several activities, the Uganda Site mainly relies on two extension agents to manage scientists and graduate student contacts with 6 participating farmer NGO groups.

There are two NGOs each at research sites in Iganga and Kumi Districts, and an informal grouping of tomato growers in Mpigi District. A pilot IPM farmer field school was conducted with a new NGO group in Kumi District this year. Maintaining direct links between scientists and farmers and providing farmers with direct feedback from research activities has been greatly facilitated by extension agents and NGO groups. This remains a constant challenge, however, requiring innovative approaches that merge research activities with information sharing and farmer technology assessment.

Planning and implementation of Uganda Site activities has emerged into a pattern that roughly mirrors the annual calendar of IPM CRSP project events. These activities seek to maximize interdisciplinary and multi-institutional collaboration and provide consistent contact between Site managers and collaborating co-PIs. An addition to this pattern was the bi-annual meeting of the African Crop Science meetings held in Morocco in mid-October. Six papers were presented at this meeting by IPM CRSP Uganda Site co-PIs and graduate students. Two USA-based Uganda Site co-PIs attended this meeting. A meeting of 17 Uganda Site co-PIs and graduate students and 6 USA-based co-PIs was held in Jinja, on March 9-10, to present brief progress reports, discuss priorities for the next year, and to develop draft work plans for Year 8. Immediately following this meeting, USA co-PIs traveled to respective research sites to discuss and plan implementation of trials prior to the beginning of the first rainy season. The Year 8 draft was discussed with two Deputy Director Generals of NARO, USAID/Kampala, and the Chief of Party of the USAID funded Investing in Developing Export Agriculture Project (IDEA). A final draft of the work plan and budget was then presented at the IPM CRSP Annual Meeting, held at Virginia Tech in May, 2000. A final event in the annual calendar was the Annual Report Preparation Meeting held in Entebbe in mid-September. The purpose of this meeting was to motivate co-PIs to analyze data from the previous two growing seasons; to initiate annual report preparations; and to discuss journal article preparation and submission. At this meeting 21 draft papers were presented to the 16 co-PIs and graduate students in attendance. These two general meetings helped integrate research findings, expose research to multi-disciplinary perspectives, and provide an opportunity for discussions of general program implementation. Research activity trials are implemented during the two rainy seasons: the longer rainy season roughly extends from April through early July, and the short rains extend from October through December.

Planning and implementation of IPM CRSP activities in Uganda continues to involve communication and collaboration with USAID/Kampala, the IDEA Project, the Rockefeller Foundation through the Makerere University Legume Improvement Program, germplasm exchanges with IITA, CIP, ICRISAT, a USDA potato research program, and CIMMYT/Harare. Representatives from CIP and ICIPE were present at the work plan meeting held in Jinja. Research collaboration with ICIPE and the Rockefeller Foundation have provided opportunities to cost share graduate student activities at Makerere University. As an indication of USAID/Kampala's support of IPM CRSP efforts in Uganda, the Mission provided support funds to the IPM CRSP to manage a Technical Assistance research effort on coffee wilt (*Fusarium xylarioides*).

IPM Constraints Addressed

The primary IPM constraints addressed at the Uganda Site are: 1) poor linkages between research scientists and farmers that ensure research activities are driven by farmer demand and adapted to farmer socioeconomic conditions; 2) 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 important horticultural crops including tomatoes and potatoes; 3) research fragmentation caused by insufficient integration of 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 verified through the initial baseline survey, 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. For example, farmer field pest monitoring activities indicated that the bean fly (*Ophiomyia* sp) was a critical yield reducing agent that prior to this activity was unrecognized by farmers. A survey of maize pests and diseases indicated that gray leaf spot (*Cercospora zeae-maydis*) was a seasonally important foliar disease and that termites (*Macrotermes*) were causing significant stand losses. Recently, the groundnut leaf miner (*Aproarema modicella* Deventer) and thrips (*Thrips palmi* Karny, *Frankliniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus*) were determined by farmers and scientists respectively, to be important pests on groundnuts. 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 striga; and, the use of several locally available bio-rational products in post-harvest storage to reduce bruchid damage.

The frequent use of chemical pesticides on cowpea and groundnuts was first documented during the initial PA and the latter two baseline surveys. On-farm trials have successfully demonstrated that a combination of cultural practices and three well-timed spray applications can reduce pesticide applications and farmer exposure to pesticides while maintaining yields. Intra-institutional cooperation has resulted in the incorporation of improved germplasm to reduce the incidence of major diseases on groundnuts, potatoes and tomatoes. Institutional cooperation has also been facilitated by the use of Makerere University graduate students to conduct field trials. ICIPE, NAARI's Biological Control Unit and Maize Research Team, Dr. H. Willson and

Makerere University scientists combined to provide financial and technical support for MU graduate student, Ms. Teddy Kauma, to rear, release and monitor the introduced parasitoid *Cotesia flavipes*. Scientists from SAARI, MU, and the USA supervise MU graduate student Mr. Robert Opulot's work. Graduate student work on identifying insect pests of cowpea and timing of chemical spray applications has been supported by the Rockefeller Foundation and has been integrated into IPM CRSP work on cowpea.

The integration of various disciplines is still a work in progress. Team meetings, at which research work plans and results are discussed with a multi-disciplinary audience, provide a useful platform to exchange disciplinary perspectives. Interdisciplinary work has been greatly augmented by the integration of social science assessments of component IPM technologies for priority crops. The inclusion of co-PIs from various disciplines in PA activities, farmer open days and farmer trial assessments has helped expose biological scientists to the importance of including a farmer knowledge perspective into their own work. It has also helped generate demand for social science assessments in order to help ensure that trial design and technology development take into consideration farmers' social and economic constraints.

Research on strategies to disseminate IPM CRSP results to a broader farm audience has only recently been undertaken. Analyses of the follow-up baseline survey indicate that sole reliance on participatory activities, such as on-farm trials, may not result in rapid diffusion of most IPM technologies. Farmer open days appear to reach a broader audience, as have fact sheets. The IDEA Project has assisted in the printing and distribution of fact sheets on stalk borer, bean fly and gray leaf spot. This year the Uganda Site implemented a farmer field school on IPM management of groundnut and cowpea as a pilot effort to expand and intensify IPM training.

Regionalization of IPM CRSP activities has largely been promoted through the participation of co-PIs in regional fora including the All African Crop Science Society, the International Association for Farming Systems Research, the Rockefeller Forum, collaboration with ICIPE, and the Gray Leaf Spot Collaborative Network and Africa Link. Multi national and institutional collaboration to identify genetic resistance to gray leaf spot, the number one foliar disease of maize in the US corn belt, is the best example of IPM CRSP Uganda Site activities directly benefiting the USA.

Selected Research Accomplishments

- *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.

- Past research by the IPM CRSP has confirmed the widespread distribution of Gray leaf spot (*Cercospora zeae-maydis*) in Uganda. Developing resistant varieties and enhanced understanding of the epidemiology of the disease are necessary to provide effective GLS management strategies. In order to more efficiently breed resistant

germplasm, screening methods that do not rely on natural infection are needed. During a four-month study conducted at OARDC, Wooster, graduate student (Godfrey Asea, Makerere University) conducted inoculation experiments in order to develop an effective greenhouse assay. Four methods of inoculation were tested and a hypodermic injection method was determined to be as effective and less laborious than other methods.

- OSU graduate student, Stuart Gordon, continued quantitative trait locus (QTL) mapping studies in Ohio. Phenotypic disease reactions of segregating progenies from a resistant X susceptible cross were obtained from one location. Identification of simple sequence repeat (SSR) polymorphisms between the resistant and susceptible parents was continued, and approximately three-fourths of the genome is now covered by suitable markers. Preliminary analyses have identified one major resistance QTL that is consistent across U.S. and African tests.

- Stover (maize residue) is widely used in Central Uganda for mulching bananas. Planting a susceptible local variety LP16 in fields containing infested maize residue demonstrated that distance from residue source significantly affected foliar damage, but direction from the residue foci did not significantly affect disease level, nor was distance by direction interaction significant in both seasons and locations. However, residue level (percentage soil cover) by distance interactions were significant. Gray leaf spot severity, area under disease progress curves, and disease intercepts decreased with increasing distance from the inoculum source.

- Field and laboratory investigations were continued to examine the traditional practice of interplanting *Celosia argentia* (locally known as Striga chaser) with sorghum to control *Striga*. *Celosia argentia* reduced *Striga* emergence on sorghum by 61% and increased sorghum yield by 51% on average over the two seasons of this study compared to sole-cropped sorghum. The laboratory study revealed that *C. argentia* can induce suicidal germination of *Striga* seeds. Thus it can also be used in short-term fallows to reduce *Striga* seed numbers in the soil.

- An economic assessment of these striga control treatments using data from two seasons in 1999, indicates that all treatments involving the farmers' variety have negative net benefits. Only treatments involving the improved sorghum variety, Seredo, had positive net benefits.

- A third season rotation experiment was conducted in order to evaluate the effectiveness of rotating sorghum with trap crops (cowpea and cotton) to manage *Striga*. The accumulated evidence indicates that growing cowpea and cotton in sequence for two seasons before planting sorghum reduces *Striga* seed numbers in the soil by 77.5%. This indicates that use of trap crops in rotation with sorghum is an effective long-term management strategy of *Striga* in heavily infested fields.

- Farmers in Iganga District now rank termites (*Macrotermes*) as the second most important pest on maize. Local farmer knowledge indicated that predatory ant species might effectively control termites. An innovative biological control strategy for enhancing ant (*Lepisiota* sp.) activity was initiated in Year 6. This strategy called for the application of protein (powdered fish) or sugar-based (molasses) baits in maize fields to attract and concentrate ants in maize fields. The protein-based baits attracted significantly larger numbers of ants compared to

molasses and resulted in greater ant nesting near maize plants. There was significantly higher termite damage in plots of maize without baits than those with baits. Maize yields in fish-treated plots were 36.2% higher than yields in control plots suggesting that ant predation was a major factor in reducing pest damage.

- In Year 6 the efficacy of using biorational products, solarization, and synthetic insecticides to control bruchid damage (*Acanthoscelides obtectus* and *Callosobruchus* spp) in stored beans and cowpea was compared. The most effective post-harvest treatments for beans in controlling damage were tobacco dust, Actellic, ash, and solarization. Solarization, tephrosia and tobacco were the most effective treatments for cowpea.

- In Year 7 an economic viability assessment of these same treatments was undertaken. This analysis indicated that wood ash, solarization, tephrosia, and tobacco provided economically viable post-harvest protection of beans and 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 opportunity cost.

- At IPM CRSP research sites in Eastern Uganda, cowpea is the crop most likely to be sprayed frequently with chemical pesticides. Two pest management packages that integrate well timed insecticide spray applications (once each at budding, flowering and podding) with cultural practices including early planting, intercropping and/or manipulated plant densities, planting and/or cowpea/sorghum intercrop have been found to be effective in reducing insect pests on cowpea and increasing grain yield by over 90%.

- The economic injury level (EIL) for thrips (*Megalurothrips sjostedti*), one of the most important insect pests on cowpea, has been established at 12 thrips per flower. The relationship between thrips population density and cowpea grain yield loss has been demonstrated to be linear and negative.

- Controlling podding pests of cowpeas in the field was found to significantly reduce bruchid carryover in storage. There was a positive and significant relationship between pod damage by field pests (*Riptortus* spp., *Nezara viridula*, *Acanthomia* spp., *Anoplocnemis* and *Maruca* sp.) and bruchid infestation in storage. Use of botanicals and synthetic insecticides to control field podding pests resulted in reduced bruchid (*Callosobruchus chinesis*) infestation in storage.

- A great diversity of arthropod predators exists in the cowpea cropping system. An initial study indicates that ladybird beetles (Coccinellidae), ground beetles (Carabidae), Assassin bugs (Reduviidae), and spiders are the most prevalent predators; while members of Braconidae, Chalcididae and Ichneumonidae were among the common parasitoids. These natural enemies were most prevalent during the flowering and podding phases.

- Field trials on groundnuts have focused on developing an integrated pest and disease management package to control groundnut rosette virus disease, aphids (*Aphis craccivora* Koch the vector of rosette disease) and Cercospora leaf-spot (*Cercospora arachidicola*). Data indicate that an effective IPM package for groundnut would be comprised of a combination of cultural, host plant resistance and reduced pesticide usage. Recommended cultural practices would be early planting (after the on-set of rains), an intermediate plant density (45 x 15 cm^2), and the use of the rosette resistant variety Igola-1. An intermediate plant density is recommended because the highest plant density (330,000 plants/ha) had the lowest incidence of rosette while the lowest plant density (60,000 plants/ha) had the lowest incidence of Cercospora leaf spot.

- Marginal Rate of Return analyses indicate that spraying 2-3 times with pesticides was most efficacious. Spraying groundnut more than 3 times increased the severity of leaf miner damage.

- Twelve introduced genotypes from ICRISAT indicated consistent resistance to rosette and thirteen showed resistance to Cercospora leaf spot. In addition, a study launched this year established the importance of several new pests on groundnut including groundnut leaf miner (*Aroarema modicella*), foot rot (*Sclerotium rolfsii*) and thrips (*Thrips palmi* Karny, *Frankliniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus*).

- For three seasons, the main disease observed on tomatoes was late blight (*Phytophthora infestans*) and the main insect pest was thrips (*Thrips tabaci* and *Frankliniella* sp.). On-farm and station trials revealed that late blight is best controlled by two applications of Dithane M45 per week during heavy rains and one spray per week during dry spells. All fungicide treatments increased thrips populations by over 60% compared to the control. Use of cover crop (*Macroptilium atropurpureum*) had no impact on disease suppression; however, it suppressed weeds by 36-45%, and in combination with reduced fungicide treatments registered lower thrips infestations. The combination of pre-established cover crop mulch and baker's yeast provided the most effective control of thrips. Of the three bacterial wilt (*Ralstonia solanacearum)* tolerant varieties introduced, farmers indicate a preference for MT56 because of its heavier flowering and fruit setting.

- 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.

- Mycotoxigenic moulds that were isolated and identified include *Aspergillus*, *Fusarium* and *Penicillium* species. They occurred in greater quantities in samples stored for 5-7 months than in newly harvested samples. In Kumi, 48% of the groundnuts stored 5-7 months and 28% of those newly harvested tested positive for aflatoxin. In Iganga, 50% of the groundnuts and 40% of the maize stored 5-7 months tested positive. No aflatoxins were found from newly harvested maize. Generally, positive samples had low levels of aflatoxins.

- CRSP activities are having a positive impact on knowledge and awareness of IPM and

crop specific pest management practices among project participants in Eastern Uganda. A survey of 200 farmers at or near IPM CRSP research sites in Eastern Uganda was used to evaluate the impact of IPM CRSP activities to-date on farmers' knowledge and awareness of IPM and crop specific pest management knowledge. A one-way analysis of variance test indicated that as project participation increased so did knowledge of IPM. Mean scores on the IPM Knowledge Scale went up dramatically and significantly at each level of participation. The impact of project participation on knowledge of crop specific management practices, assessed using a t-test for equality of means, indicated that for each set of crop specific test questions, significant knowledge differences occured between non-participants and participants in IPM CRSP activities.

- Using ex-ante economic surplus analysis to assess the aggregate benefits to the Ugandan economy of two IPM CRSP interventions demonstrates that the maize variety, Longe-1, and seed dressing for beans give higher net returns than farmers' practices and that efforts should now turn to promoting further adoption of these two technologies.

Institution Building

The IPM CRSP Uganda Site has placed a great deal of emphasis on human resource development. Graduate student training at Makerere University has helped facilitate domestic and international institutional collaboration and has contributed to research output. Five Ugandan graduate students have completed or are in the final stages of completing their MS degrees. One of these students recently accepted a position with the CIAT program in Uganda. Two Ugandans spent 2-3 months in the USA receiving specialized training. Mr. Godfrey Asea spent several months at The Ohio State University Research Station (OARDC) conducting greenhouse inoculation experiments as part of the activity on gray leaf spot. Upon his return to Uganda he repeated his experiments and this has already led to submission of a journal article. Mr. Archileo Kaaya spent 2 months at Virginia Tech developing laboratory procedures for isolating and identifying fungal pathogens infecting maize and groundnuts. Application of these procedures upon his return to Uganda has again led to the submission of a journal article. In July, Ms. Jackline Bonabana, formerly from Makerere University, joined Virginia Tech to complete her M.S. degree in Agricultural Economics.

USA based co-PIs made eight trips to the Uganda Site this year. In early December, Dr. Luther worked with Dr. Kyamanywa and an undergraduate student to devise a field methodology for the identification of beneficials. The annual work plan development meeting held in Jinja, Uganda, March 9-10, was attended by Drs Gebrekidan, Erbaugh, Warren, Willson, Taylor and Bhagsari. While in Uganda at this time, Drs Warren, Willson, and Taylor provided special lectures to students at Makerere University, and Drs. Erbaugh and Willson helped design and inaugurate the Pilot farmer-training program. Dr. Erbaugh returned to Uganda in early September to Chair the Annual Report Preparation Meeting. Drs. Kyamanywa and Hakiza traveled to the USA to participate in the IPM CRSP Annual Conference held at Virginia Tech.

Networking

Networking in Uganda has already been described. It is facilitated by the functional links between the Site and Deputy Site Chairs and their respective organizations. These linkages are reinforced by courtesy visits made by USA based co-PIs, usually in the company of the Site Chair, to the Director General of

NARO, to the Dean Faculty of Agriculture and to Directors of participating research institutes. Meetings with USAID/Kampala are also facilitated by these visits. Preliminary research results are presented by co-PIs at the two annual meetings held in Uganda. Two IPM CRSP Ugandan co-PIs presented their research findings to special symposia hosted by the IDEA Project. Visits by the Site Chair always include update meetings with USAID/Kampala and other USAID sponsored programs such as IDEA and ACDI/VOCA. Personnel from both the IDEA Project and ACDI/VOCA are well acquainted with the Site Chair and Coordinator and include them in meetings pertaining to IPM and pesticide regulatory compliance.

Regional networking is conducted via 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. Direct communication between Uganda co-PIs and USA co-PIs have resulted in germplasm exchanges with IITA, CIP, ICRISAT, a USDA potato research program, and CIMMYT/Harare. Regional representatives from CIP and ICIPE participated in this year's work plan development meetings. This year Uganda co-PIs and graduate students and USA based co-PIs presented papers at the All African Crop Science Society meetings held in Casablanca, Morocco. The IPM CRSP was the only CRSP represented at this meeting. Drs Willson and Kyamanywa and graduate student Teddy Kauma recently presented findings at the ICIPE hosted International Workshop and Conference on the Status and Advances in Biological Control of Cereal Stem Borers in Africa, held in Nairobi, Kenya. Additionally, Drs. Kyamanywa and Hakiza participated in the IPM CRSP Annual Conference held in Blacksburg, Virginia.

Research results are also disseminated through publications. This year there are eleven articles that have been accepted for publication and an additional six that have been submitted.

LATIN AMERICAN REGION

Guatemala / Honduras

Glenn H. Sullivan, Site Chair, Purdue University, West Lafayette, Indiana; Guillermo E. Sánchez, Site Coordinator, Universidad del Valle, Guatemala City, Guatemala; and Stephen C. Weller, Co-Principal Investigator, Purdue University, West Lafayette, Indiana

Description of the Collaborative Program

The IPM CRSP Central American Site operates through a site committee structure, with Guatemala as the prime site. Dr. Guillermo Sánchez, Head of the Department of Agricultural Sciences and Forestry at the Universidad of del Valle, serves as the regional site coordinator for Central America. The Regional Site Committee is comprised of Dr. Sánchez and Jorge Sandoval (UVG), Ing. Luis Calderón, Danilo Dardón, (ICTA), Juan Enrique Leal (Soluciones Analíticas), Luis Alvarez (ARF/AGEXPRONT), Jorge Mario Santos (MAGA), Luis Caniz (APHIS-IS), Linda Asturias (ESTUDIO 1360), and Maria Mercedes Doyle (ZAMORANO). The U.S. researchers that collaborate with the regional site committee and provide research support, technical support, and program coordination include: Drs. Glenn H. Sullivan, U.S. Site Chair; Stephen C. Weller; C. Richard Edwards; and Ray Martyn (Purdue University); and Sarah Hamilton (Adjunct Professor-Virginia Tech). The overall Central American site activities in Year Seven were funded through U.S. IPM CRSP under subcontract with Virginia Tech, and grant funds generated from the Government of Guatemala

(GOG) and ARF/AGEXPRONT. Grant proposals to APHIS, FAO, the Ministry of Agriculture/Honduras, and the Government of Guatemala were developed in Year Seven for IPM CRSP research activities in Year Eight.

ZAMORANO (Honduras) was the principal regional collaborating institution outside Guatemala. In Year Seven, however, substantive discussions were carried forward with Nicaragua and the Ministry of Agriculture in Honduras with the purpose of establishing MOU's in these countries during Year Eight.

APHIS and ARF/AGEXPRONT continued to provide strong collaborations in the development of IPM / 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 of preinspection programs in Guatemala. ICTA and UVG have collaborated 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.

Research collaborations with MAGA and ICTA were strengthened in Year Seven. MAGA proceeded to revise their domestic development programs in Guatemala commensurate with IPM CRSP program priorities, including community level transfers of IPM CRSP developed production strategies and protocols. GOG grants to the IPM CRSP researchers at Universidad del Valle and AGEXPRONT provided funds for community level research transfer activities and training, including field demonstration.

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 monthly 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.

IPM Constraints Addressed

Institutional policies

The need for continuity and enforcement of public and private sector policies continues to influence NTAE development in Central America, including the implementation and institutionalization of performance-proven IPM/ICM production practices and certified preinspection programs. In Guatemala, the private sector has led initiatives for policy revision, with the GOG assuming a more proactive role in Year Seven. AGEXPRONT, in collaboration with the IPM CRSP, has played a central role in developing serious efforts to develop more proactive production and post-harvest policies that serve to enhance performers in the NTAE sector. Science-based production and preinspection policies that lead to reduced pesticide usage and decreased product rejections at U.S. ports-of-entry continue to be the major focus. MAGA endorsed these efforts in Year Seven through programs that encourage substantive adoption at the national level. GOG initiatives to revise policies commensurate with the demands of a

more competitive marketplace in the NTAE sector are now receiving serious consideration.

Technology Transfers

It is evident that far too many small independent NTAE producers still rely heavily on chemical control practices and unregistered pesticides for insect and disease control. This constraint is gradually being overcome as more IPM CRSP approved pest management information is transferred through grower workshops, technician seminars, and field demonstrations. We estimate that approximately 45 percent of Guatemala's NTAE producers were engaged in the use of approved IPM CRSP pest management practices in Year Seven. Over 75 field technicians and 500 NTAE growers received IPM CRSP approved ICM information and training in Year Seven. ICTA, AGEXPRONT, and PIPAA (Integrated Program for Protection of Environment and Agriculture, GOG) played important roles in these training and technology transfers in Year Seven.

Research Capacity

Capacity to undertake science-based research within the collaborating institutions and among the individual collaborators has been a serious constraint to the implementation of good management practices in the NTAE sector of Central America. Many of the collaborators have simply lacked the scientific experience to bring science-based solutions to current pest problems. In Year Seven, we made significant progress in overcoming this constraint, particularly in Guatemala. We now have a "critical mass" of trained field technicians who are capable of addressing pest management problems using applied science-based protocols. Again, AGEXPRONT and ICTA, in collaboration with IPM CRSP researchers, have played an important role in achieving these results. In Honduras, the Ministry of Agriculture has confirmed its interest to follow the science-based pest management models developed by the IPM CRSP in Guatemala. The Ministry of Agriculture has agreed to fund a $100,000 research initiative in Year Eight titled "Identification, distribution and epidemiology of plant virus pathogens that threaten pepper / tomato and cucurbit production in Honduras and Guatemala". This research project will be directed by Dr. Ray Martyn (Purdue) and Dr. M. Doyle (Zamorano), in collaboration with Drs. G. Sánchez (Site Coordinator), S. Weller and R. Edwards (Purdue).

Selected Research Accomplishments

- The premier accomplishment in Year Seven is the formalization and institutionalization of the preinspection program for snow peas in Guatemala. The IPM CRSP research collaborators invested over three years of effort into developing and testing the performance protocols at the production and postharvest levels. This research now serves as the foundation of Guatemala's NTAE preinspection program which was institutionalized in Year Seven with PIPAA as the administrative entity for the GOG/MAGA.

- The importance of this research accomplishment centers upon the fact that Guatemala's competitive position in the NTAE sector has suffered since 1995 due to sanitary and phytosanitary violations detected at U.S. ports-of-entry. In Guatemala, and throughout the Central American Region, the need for a program that controls the product's quality at the point-of-origin is critical to future expansion in the NTAE sector. After two years of field trials the IPM CRSP and its collaborators clearly demonstrated that high quality snow peas meeting all sanitary and phytosanitary regulations could be produced with the technology currently available when properly implemented and precisely managed. These results have been the basis for the field and post-harvest handling protocols to be followed in the pre-

inspection program and administered by PIPAA.

- Our research finds that economically sustainable expansion in the Central American NTAE sector will substantially depend upon the industry's capacity to address increasingly important aforementioned non-economic constraints to interregional trade. An assessment of U.S. trade data suggests that there is a correlation between the lack of compliance with the aforementioned non-economic constraints and a decline in Guatemala's competitive position in the U.S. vegetable market. The IPM CRSP is playing a pivotal role in helping reestablish regional competitiveness in the NTAE sector.

- The development of biorational alternatives to methyl bromide was an important research activity that led to positive results in year Seven. ICTA provided the leadership role in this research activity, with input from U.S. IPM CRSP collaborators. Various alternatives to methyl bromide fumigation were developed and tested in broccoli and tomatoes to determine their potential in weed, nematode, and clubroot control. Findings concluded that effective pest management could be achieved using strategies that included solarization and vapam in a biorational manner. This important research was accomplished with private sector funding in the amount of $300,000 USD, and was initiated in part as a result of a research paper published by IPM CRSP collaborators J. Julian, G. Sullivan, and S. Weller in 1998.

- IPM CRSP research activities centering on NTAE trade and market development continue to serve as an important catalyst for new funding initiatives. Recently published research findings have resulted in GOG funding in the amount of $750,000 USD to establish a fully integrated supply consolidation, preinspection, and distribution center in the District of Chimaltenango. Further, research findings assessing the impact of food safety protocols on future development in the NTAE sector of Central America have motivated APHIS-IS to request IPM CRSP researchers to submit a proposal in the amount of $450,000 USD to assess and develop pest risk management protocols for five additional NTAE crops that exhibit opportunity in U.S. markets. In addition, FAS has invited IPM CRSP researchers to submit a proposal in the amount of $350,000 USD to assess health and food safety issues in the NTAE sector. These funding opportunities help to significantly leverage baseline funding from the USAID sponsored IPM CRSP, and establish the basis for sustainable program results in Central America.

- In addressing the plant virus disease problems in Honduras, IPM CRSP researchers and collaborating institutions identified four different plant begomoviruses known elsewhere in Solanaceous (TPV,PHV) and bean (BGMV) crops and discovered at least five new, previously undescribed begomovirus (whitefly-transmitted geminiviruses of tomato and pepper). In addition, nine different, well-known aphid–transmitted (RNA containing) viruses were detected in watermelon and pepper samples.

- These first year activities have resulted in the beginnings of an excellent foundation for establishing the first baseline inventory of plant viruses in Solanaceous-Cucurbitaceous cropping systems of Honduras. Further, these research activities served to establish preliminary approval for grant funding in the amount of $100,000 USD through the Ministry of Agriculture in Honduras to establish a collaborative research initiative for more substantively addressing the virus

disease problems in melons starting in Year Eight.

- While findings from the socioeconomic research activities conducted by IPM CRSP researchers are still preliminary, important gender conclusions were established in Year Seven. The most significant finding from this research is the fact that women do have a strong voice in the control of household land use and income distribution related to commercial NTAE production in the highland communities of Guatemala. This evolving role of women in NTAE production is a change from past experiences reported in research pre-dating IPM CRSP. The gender and socioeconomic research collaborations will be expanded in Year Eight through supplemental funding from the GOG, and directed under the leadership of Dr. Sarah Hamilton, Virginia Tech.

- The white fly-geminivirus complex has been a pest of great importance in tomatoes in the last few years. It has become difficult to grow tomatoes successfully and, in many cases, the crop has been abandoned by many farmers or farmers have moved fields to less severely infested areas. The integrated whitefly management (IWFM) package developed by IPM CRSP researchers included the following components: 1) seedling transplants (in contrast to seedbed seedlings) from covered seedbeds, 2) sorghum live barriers, 3) utilization of economic damage thresholds (EDT) for insecticide applications against whifeflies and other insect pests, and 4) two meter tall peripheral 50mesh plastic screen. The IWFM technology was contrasted with a local farmer's management. Results showed that the final viral incidence averaged 17 percent in the IWFM plots in contrast to 25 percent in the control. The total yield in the IWFM plots was superior to that of the farmers by 16,326 Kg. The benefit/cost relationship is roughly 10.5 (US$ 1/Q7.8, exchange rate) for the IWFM plot, equivalent to approximately 1.2 dollars for every 15 cents invested. The benefit/cost ratio in the farmers plot was 7.70. The variable costs were smaller in the IWFM plots, in contrast to the farmers' technology. Crop yields were also greater, therefore, IWFM was more profitable than the farmer's technology. These results will encourage farmers to adopt this new technology and allow tomatoes to be a profitable agricultural enterprise.

- Snow pea is a very important non-traditional agricultural export (NTAE) crop in Guatemala. This crop has allowed many growers which were previously subsistence farmers to become involved in export agriculture. The pea leaf miner *Liriomyza huidobrensis* (Blanchard) has recently become the most important pest of snow peas, *Pisum sativum* L. in Guatemala. The cosmetic damage created by the leaf miner larvae as they tunnel through the snow pea pods is of great concern to growers and exporters. Such damage is often unnoticeable until the product has reached the U.S. ports-of-entry. This pest has created additional concern because it is believed that it has developed resistance to the insecticides that are labeled for its control. The objective of this research was to investigate IPM techniques which would reduce leaf miner populations in snow pea fields.

- Results of choice and no choice laboratory experiments indicate that faba beans are a preferred host for oviposition over snow peas. A higher number of eggs and greater larval emergence were observed on faba beans both in the presence and in the absence of snow peas. Faba beans used as a trap crop in field experiments during the rainy season resulted in a significant

reduction in leaf miner populations. Results of the research indicated that the IPM pest management strategies including faba beans as a trap crop are effective in reducing leaf miner populations in snow pea fields.

Institution Building

The Government of Guatemala, through MAGA and ICTA, has strongly supported the IPM CRSP's overall objectives for strengthening scientific capacity and market-focused planning in the NTAE sector. These institutional linkages continue to be important factors in moving the IPM CRSP research and development agenda forward in Central America. In Year Seven, the GOG gave preliminary approval for the development of a $750,000 USD NTAE supply consolidation, preinspection, and forward distribution center in the Chimaltenango region. This center will be developed under the guidelines established by IPM CRSP, and in collaboration with MAGA, ICTA, APHIS, AGEXPRONT, ICADA, and three private sector NTAE exporters. This GOG commitment provides clear evidence of the IPM CRSP's role in institution building in Central America. In addition, institutional collaborations with FAS and FAO have been critically important in helping develop additional program funding and capacity for the IPM CRSP.

Efforts continued in Year Seven to strengthen institutional collaborations in Honduras through the Ministry of Agriculture, in collaboration with Zamorano and FHIA. IPM CRSP research agendas were presented to the Ministry of Agriculture for funding in Year Eight. These activities have been given preliminary approval, and the Ministry of Agriculture is expected to request the signing of a MOU with the IPM CRSP Management Entity during the first quarter of 2001.

The IPM CRSP in Central America continues to place 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.

Student Training

Jim Julian, a U.S. citizen, is working on his Ph.D. under the direction of Dr. Glenn H. Sullivan at Purdue University. His research and training focuses on the impact of non-economic constraints to trade in the NTAE sector of Central America, including food safety and regulatory compliance issues.

Carlos Mayen, a native Guatemalan, completed a summer internship at Purdue University in the 1999 summer term, and now is working on his Master's Degree under Dr. Stephen C. Weller in the Horticulture Department at Purdue University. His research and training is in biorational pest management strategies for Central America NTAE crops.

Carlos Ludéna, a native Ecuadoran who became associated with the IPM CRSP through his training at Zamorano in Honduras, is completing his Master's Degree in the Agricultural Economics Department under the direction of Drs. Kevin McNamara and Glenn H. Sullivan. His research centers on production economics in the NTAE sector, with focus in the floriculture sector.

Gustavo Acosta, a native of Mexico with broad experience in Central America, is completing a Master's Degree in Agricultural Economics at Purdue University on a match funded assistantship under the direction of Drs. Kenneth Foster and Glenn H. Sullivan. His research centers on strategic market

development issues for Central America in the NTAE sector.

Networking

Institutional networking activities were expanded in Year Seven as preinspection policies in snow pea were institutionalized for implementation by the GOG. ICTA, MAGA, APHIS, and AGEXPRONT continued to play important collaborative roles in preinspection research and development. In addition, PIPAA, a joint MAGA/private sector entity was commissioned to handle preinspection program implementation, compliance, and enforcement in Guatemala's NTAE sector. This important networking activity required a substantive commitment from the IPM CRSP in training and knowledge transfers.

Networking activities at the district and community levels were expanded in Year Seven. 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.

Collaborations with APHIS-IS in the development and testing of preinspection programs have helped further expand the IPM CRSP networking activities in Year Seven. Private sector grower-shippers and shippers of NTAE crops that are participating in the IPM CRSP led initiative became important "conduits" for technology transfers, potentially reaching nearly 13,000 small farm producers, field technicians, and community leaders throughout Guatemala and Central America.

The IPM CRSP strengthened networking activities in Honduras in Year Seven, initiating direct communications and site visits with the Minister of Agriculture, the Ministry's Coordinator for Technology Generation, and FHIA. The Minister of Agriculture, Guillermo Alvarado Downing, requested an IPM CRSP developed research proposal 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 and Maria Mercedes Doyle at Zamorano, responded to Minister Downing's request for a research proposal to address these plant disease problems, and a $100,000 USD budget for Year Eight has been given preliminary approval. It is noteworthy that these initiatives in Honduras included interCRSPing networking activities with the Bean Cowpea CRSP.

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 ringspot potyvirus in papaya. These networking activities will likely be expanded and strengthened in Year Eight through a stronger collaboration with researchers at the University of Georgia and additional funding.

The IPM CRSP strengthened regional collaborations with AGRITRADE and AGEXPRONT through assistance in the development of the 1999 Regional AGRITRADE Conference. This important conference includes public and private sector participants from throughout the region (Guatemala, El Salvador, Nicaragua, Honduras,

and Costa Rica). The IPM CRSP portion of AGRITRADE program focuses on "Food Safety and Implications for Market Development in the NTAE Sector". Drs. Sullivan, Sánchez, and Weller are the lead IPM CRSP participant in the 1999 AGRITRADE Conference. Participation in this program has led to further discussion on IPM CRSP regionalization with Nicaragua and El Salvador.

IPM CRSP socioeconomic networking activities were strengthened in Year Eight through efforts of Drs. Sarah Hamilton at Virginia Tech and Linda Asturias at ESTUDIO 1360. Gender and socioeconomic impact studies were conducted at the community level in Guatemala, and integrated databases were developed through collaborative efforts with Dr. Edward Fisher of Vanderbilt University. Dr. Fisher has been conducting socioeconomic studies in Central America and agreed to share his database with IPM CRSP researchers on a quid-pro-quo basis. This networking activity has greatly enhanced the socioeconomic knowledge base of the IPM CRSP, and is expected to generate important gender, household, and NTAE impact conclusions for publication in Year Eight.

Ecuador

Jeff Alwang, Site Chair, Virginia Tech
Carmon Suarez, Lowlands Site Coordinator, INIAP, Pichilingue
Patricio Gallegos, Highlands Site Coordinator, INIAP, St. Catalina

Description of the Collaborative Program

This is the third year of activity at the South American site in Ecuador. A total of 10 major activities and two special projects 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. Two site coordinators manage activities under the CRSP because the crops we work with are primarily located in two locations. Patricio Gallegos serves as the Site Coordinator for the higher elevations. He coordinates activities with potato and Andean fruits. Carmen Suárez serves as Site Coordinator for the lower elevations. She is a researcher at the INIAP Tropical Experimental Station at Pichilingue and coordinates plantain activities. Each activity has a leader that is responsible for interactions with their respective coordinators and cooperators.

The work under the CRSP was conducted as a collaborative effort among scientists at INIAP, the International Potato Center (CIP), the National Potato Program (FORTIPAPA), PROEXANT, the International Food Policy Research Institute (IFPRI), Fundacion Maquipucuna, Eco-Salud, the Soil Management CRSP, the University of Georgia, the 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 7 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, and b) preparation of joint host-country/US/international scientist two-page proposals.

Field research is being conducted in farmers' fields in Chimborazo, Carchi, El Carmen, Maquipucuna, with INIAP/CIP scientists visiting experiments on a regular basis. Research is also conducted on station, at Sta. Catalina and Pichincha, especially varietal

screening for insect, disease, and nematode resistance.

IPM Constraints Addressed

The key constraints addressed in Ecuador in year 7 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 socioeconomic factors influencing adoption of IPM and 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; Babaco and Narajilla Vascular Wilt (caused by *Fusarium oxysporum*) and other pathogens in Andean fruits; and Black Sigatoka (caused by *Micosphaerela fijensis*), the bacteria *Erwina sp*, and several insect pests in plantain.

The site is thus addressing some of the known production constraints of some 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. Plantain is a staple food for people living in the littoral (lowland Tropics). In fact, plantain is a substitute for potatoes at the lower elevations.

The plantain research is especially important, as there has been very little study worldwide of IPM practices for plantain. It was originally assumed that many banana practices could be directly transferred to plantain. However, our research is showing that not to be the case. One 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 some significant accomplishments:

- The IPM CRSP identified two new products for potential use against the Andean weevil in potato. Etofenprox and Triflumuron, both of which have very low mammalian toxicity, were tested, and Triflumuron has been shown to have promise in combating the pest.

- We found mixed results for control of Central American Tuber Moth damage in stored tubers. Control with Baculovirus showed a resulting 30.4% damage, while control of the moth with Carbaryl yielded damage of 14.%. Control methods still need to be improved.

- Several potato cultivars have been identified that are acceptable to consumers, and have strong (horizontal) resistance to late blight. A survey of the incidence and importance of the major potato diseases has also been conducted.

- A field day was held to share the results of control of weevil grubs. Field day was attended by 25 students and faculty from the San Jorge de San Gabriel High School. Another field day was conducted at Chimborazo; this course was attended by 20 farmers and 2 technicians.

- Mite control strategies for babaco in the greenhouse have shown that there are several effective materials available; when these materials are combined, the treatment is almost 100% effective.

- Three accessions of the Caricaceae family have been identified as resistant to *F. oxysporum* which causes babaco vascular wilt. These accessions, *C. monoica*, *C. papaya* and *C. weberbaueri* can be used as resistant root stocks.

- Weeds can be used to produce high-quality humus in the Ecuadorian highlands. This alternative used of formerly wasted resources shows some promise for the maintenance of soil fertility in the future.

- 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.

- Problems in plantains, and strategies for their control, have been shown, contrary to prior expectations, to be different from those of bananas.

- Main plantain problems of Black Sigatoka and Black Weevil (*Cosmopolites sordidus*) have been identified. IPM strategies for control of Black Sigatoka lead to higher plantain yields than farmer or commercial practices. The common plantain variety has been shown to be more resistant to disease than dwarf varieties.

- 79 farmers in 4 communities are participating in a model of diffusion that involves farmer Field Schools and a participatory discovery process to promote IPM practices in Carchi and Bolivar. This practice improves the farmers' ability to analyze different practices and make decisions based on ecological knowledge of the cropping system.

- A Field School workshop was held in October 1999; a meeting in March 2000 systematized the first experiences of the Field Schools; and a short-course was held in Los Andes-Carchi in early February to discuss insects and potato pathogens. On March 11, 2000, a field day was held in San Pedro de Piartal-Carchi, and more than 150 local farmers attended.

- A baseline data set from 60 households has been collected. The data contain detailed information on agricultural practices, household demographics, and pest management practices. These data are being merged with data on illness and more detailed information on the impacts of pesticide use on household members.

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 to conduct research and to train individuals in applied agricultural research.

Mr. Franklin Maiguachca received his Eng. Agron. degree from Central University based on his thesis related to biological control of Andean weevil.

Mr. M. Arroyo received a degree in Eng. Agron. from Central University; his thesis documented the study of the efficacy of combining acaricides for control of the mite *Eotetranychus nr. Deflexus* in babaco.

Two Ecuadorian students are completing degrees in Ecuador related to the study of the economic impacts of IPM.

One of the researchers on the Andean fruit project has taken a short course on diseases at Turrialba Research Center in Costa Rica. Danilo Vera traveled to Colombia to exchange research findings related to pest management for plantains and observe practices there. Luis Escudero participated in a course entitled "Principles of Planning Activities for Integrated Vegetation Protection." This course was attended by representatives from 7 Latin American Countries and was held in Lima, Peru from March 21 through April 14, 2000.

Plans have been made for an M.S. research assistantship for one junior researcher in the U.S. beginning in the spring of 2001. A third candidate, a senior researcher, will likely start his Ph.D. in 2001.

Networking

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.

Plantain activities have been coordinated with INIBAP (the international banana research center). Dr. Sylvio Belalcazar, an international plantain expert, observed the plantain projects, and a joint INIAP/INIBAP workshop on plantain management was held in April. The plantain work has also involved local agricultural high schools and universities.

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.

The impact assessment is being conducted jointly with IFPRI and in collaboration with the Soils CRSP and CIP.

It is likely that the World Bank PROMSA project will fund at least one Ph.D. student at a U.S. university beginning in 2001. IPM CRSP funds may be used to complement the PROMSA funds.

Mutuality of Benefits of the Research

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

Potato research to find clones which have long-term resistance to late blight and that are highly acceptable to consumers will benefit Ecuador, the region and the world. This is a top priority for North America as well as for our neighbors in South America and steady progress is being made.

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.

CARIBBEAN REGION

Jamaica

Sue Tolin, Site Chair, Virginia Tech
Dionne Clarke-Harris, Site Coordinator, CARDI, Jamaica
Janet Lawrence, Outgoing Site Coordinator, CARDI, Jamaica

Description of the Collaborative Program

The activities of the Caribbean site are conducted under four main research components: IPM Systems Development; Pesticide Use, Residues and Resistance; Social-economic, Policy and Production Systems; Research Enhancement through Participatory Activities. For the 1999-2000 project year, the activities of the site were conducted mainly under the first three research components. Research activities presented herein are the collective efforts of scientists from Caribbean and US Institutions including the Caribbean Agricultural Research and Development Institute (CARDI), Ministry of Agriculture (MINAG), Rural Agricultural Development Authority (RADA), Pennsylvania State University (PSU), Virginia Polytechnic Institute and State University (VPI&SU), Ohio State University (OSU), United States Department of Agriculture - Vegetable Laboratory (USDA-VL) and Lincoln University (LU).

The overall goal is to develop IPM system components (i.e., sampling systems, decision support tools, and control tactics) and to combine these components into management systems for the three major crops (pepper, sweet potato, and vegetable *Amaranthus* or callaloo) that are being addressed by the IPM CRSP Caribbean site research team working in Jamaica. In many cases, Jamaican farmers have adopted systems of intensive pesticide application using chemicals that pose high risks to human health and the environment. In these cases, the Caribbean research team is attempting to implement a phased approach to demonstrate the benefits of eliminating these toxic materials from Jamaican agriculture and eventually the Caribbean. The first phase is to demonstrate that less toxic pesticides can produce comparable crop yields with smaller environmental and human costs; whereas, the second and most important phase is to develop and implement IPM systems that are biologically intensive and environmentally benign.

IPM Constraints Addressed

Environmentally friendly biological controls and biorational pesticides were evaluated to determine potential candidates for management of hot pepper pests. The option of pest management through resistant/tolerant cultivars was used successfully with the introduction of the “West Indian Red” cv. This provided reliable industrial quantities while the mare susceptible scotch bonnet was used to supply specialized markets.

Research was also designed to address the hypotheses that early infection of hot peppers reduced yield and quality of fruit, and that delay in infection by knowing periods of high aphid incidence would increase yield and quality.

For callaloo the current grower practices emphasize prophylactic calendar sprays for control of lepidopteran larvae, resulting in high insecticide inputs. This results in high labor and material costs, minimizes the potential for integrating other management tactics, and creates environmental, health and export constraints. Developing action thresholds would begin to manage these insecticide inputs.

Pesticides currently used against callaloo pests fail to give effective control, possibly because of the lack of resistant management protocols for pesticide use. New effective chemistries need to be identified and introduced in conjunction with the implementation of stricter management

procedures for pesticide use. Ideally, IPM seeks to minimize pesticide use in production systems with the effective use of non-chemical methods.

Sweetpotato weevils, sweetpotato leaf beetles, and the WDS (Wireworm-*Diabrotica*-*Systena*) soil insect complex significantly reduce sweetpotato 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 IPM procedures for sweetpotato farmers in the Caribbean to produce high quality products which are competitive in international markets. Dissemination of IPM technology to farmers in major sweetpotato growing areas in the Caribbean will facilitate the goal of reducing pest damage and improving sweetpotato production such that it is competitive in the global market.

Selected Research Accomplishments

- As a stop gap to the virus problem which is crippling the hot pepper industry, West Indian Red hot pepper variety was introduced into four project areas inclusive of IPM CRSP target sites. Using IPM technologies, the West Indian Red variety proved to be an economically viable crop for small farmers.

- In order to study the populations of the broadmite effectively sampling methods were developed for the broad mite and its natural enemies on hot peppers, analyzing data from a survey on the use of pesticides on hot peppers; which showed that pesticide use increased broad mite incidence, and testing the use of biorationals on hot pepper.

- Evaluation trials were conducted to assess four new biorational chemistries [Spintor® (spinosad), Confirm® (tebufenozide), Ecozin® (azadirachtin)] and Proclaim® (emamectin benzoate) for efficacy in controlling lepidopterous pests. Spintor®, Confirm®, Ecozin® and Proclaim® were more effective in control of Lepidoptera species resulting in markedly lower insect damaged losses (6.5-15.5%) in Trial 2 and (1.0-3.0%) in Trial 3 than the grower standard, Karate® (lambda cyhalothrin), plots with losses of 27.7% and 24.0 % in Trials 2 and 3, respectively.

- Callaloo plant development was monitored under three types of row covers which give 70%, 85% and 95% light transmittance, respectively, to determine the optimum light requirements for economic growth of the crop in a protected agriculture production system. There was no significant difference in total fresh weight of shoots and plant height among the treatments. Row covers with light transmittance of 70% and greater would therefore be suitable for use as an exclusion barrier to insects.

- For callaloo, two strategies (a) exclusion and (b) use of biorationals applied on the basis of pest density (1 larva per six leaf sample) have given superior plant protection against Lepidoptera species, and in the case of exclusion, against all major pests. The benefits of these strategies have been demonstrated to 25 farmers and the extension officers of five major callaloo-growing districts in St Catherine.

- Research, which has been conducted on the callaloo cropping system, has now come to fruition and the research model is thought to be applicable to other vegetable systems throughout the region, in which high pesticide input is an important concern. The proposal is for this model to be tested on cabbage systems for developing management strategies against the diamond-back moth, *Plutella xylostella.* This regionalisation effort has been initiated

through contacts in Antigua and Barbados made through the PROCICARIBE Caribbean IPM Network. This effort will be intensified in Year 8.

- Sweetpotato IPM component research focused on evaluating several dry-flesh sweetpotato breeding lines and varieties at Blackville, SC (19 entries), Charleston, SC (40 entries), Homestead, Fla. (27 entries), Basseterre, St. Kitts (10 entries), and Bodles, Jamaica (15 entries), for resistance to soil insect pests, including sweetpotato weevils, sweetpotato leaf beetles, flea beetles, and the WDS (Wireworm-*Diabrotica*-*Systena*) complex. Data from the United States indicated several new entries with insect resistance and desirable agronomic characteristics. Thus, 11 new lines from the U. S. Vegetable Laboratory were sent to Jamaica, and 19 lines were sent to St. Kitts during this reporting period. These breeding lines had been selected based on desirable skin and flesh colors, and based on their overall resistance to the insect pest complex in the United States. The replicated field test in Jamaica using USDA-developed sweetpotato clones and Caribbean varieties did not produce results consistent with previous years in terms of resistance to the sweetpotato leaf beetles, sweetpotato weevils, and/or the WDS soil insect complex. This may have been due to the poor yield resulting from slow development of tubers due to prolonged rain in the last quarter of 1999. The promising lines, in terms of yield, appear to be Picadito (US) and Tis24-98 (Jamaican), as well as Sidges (Jamaican).

- The efficacy of integrating a few varieties, which showed resistance to soil insect pests, with a selective, low toxic compound, fipronyl, garlic extract or imidachloprid was investigated. There was a significant ($P = 0.038$) difference in SPLB damage to roots among the treatments; however, only imidachloprid and fipronyl treatments were significantly ($P = 0.05$) different from each other. Plots treated with fipronyl had the lowest level of SPLB damage, with indices of 0.18, 0.31 and 0.36 for White Regal, Sidges and Picadito, respectively. Overall, White Regal treated with fipronyl gave the least damage, while White Regal treated with garlic extract gave the most damage, followed closely by Sidges treated with imidachloprid.

- The regionalisation component of the sweetpotato IPM under the project was continued after being initiated in Year 6. Researcher exchanges and visits to St Kitts and Nevis, and St Vincent provided the medium to initiate sweetpotato research and has set the stage for future expansion of the IPM CRSP research activities.

- Pepper fruit stages collected from fifteen farms showed a correlation between field infestation levels and the green mature fruit stage and less for the ripe but there was no correlation with infestation levels in other stages. Parishes with high rainfall had very high infestation levels. 51.2%% farms showed HPGM infestation, being highest in Trelawny (100%) and lowest in Westmoreland (13%). Field infestation levels averaged some 11% nationally, ranging from 0% in half of total fields sampled to 75% in Rio Hoe, St. Ann and 74% in Reach, Portland. The upland shared border areas of St. Elizabeth, Manchester and St. Ann and one area in central St. Thomas showed no infestation. Our data suggest that the pest might not be distributed island-wide. However, survey protocol breach in St. Thomas and the need for further statistical analysis and field checks preclude any such conclusion at this time.

- Sixty eight extension personnel from 12 parishes were trained during 4 workshops which covered pest biology, economic importance and protocols for conducting islandwide survey. Twenty eight field sessions were held for 446 farmers who were trained in gall midge management tactics.

- We assessed the extent to which pesticides are used on pepper, callaloo, and sweetpotato. We hypothesize that many of these pesticides remain on crops long after application even to the extent to which residues can be detected in local and export marketplaces. We have attempted to quantify pesticide use and residues that can either cause human health problems or rejection in the marketplace. Resistance to pesticides may also be a result of excessive pesticide use or of those chemicals that degrade very slowly under field conditions.

- Results of market basket surveys conducted in local markets have demonstrated that pesticide residues are present on marketable produce. In an effort to address the problem, IPM technologies geared towards reducing spray applications were developed. These technologies have been combined with new biorational chemistries and are being used on on-farm demonstration plots to show farmers the benefits and control obtained with reduced pesticide input.

- Social, economic, policy, and institutional systems (human systems) have been shown to sometimes present overwhelming barriers to implementing IPM practices. The systems evaluated by the Caribbean research team include domestic and export markets and policies and practices associated with those markets, institutions and the policy environment of Jamaican agriculture, and farmgate economics as it relates to pepper, callaloo, and sweetpotato production and marketing (local and export).

- The main export markets for fresh hot peppers from the Caribbean lie in the USA. Caribbean countries account for roughly 0.3% of US imports of fresh and chilled pepper.The monthly price trends for Jamaican Scotch Bonnet in the Miami and New York markets are consistent from year to year and there are indications that price movement is as a result of the US domestic supply situation, and not the hot pepper supply situation in Jamaica. The absolute prices for Scotch Bonnet from Caribbean and Jamaica in particular are higher than that for other varieties, as well as for Scotch Bonnet from other countries in the Miami and New York markets.

- There are limited relationships between consumer behaviour and demographic variables in the purchase and use of hot pepper products in the Miami and New York markets. In these cities there is a preference for fresh hot peppers that are red and green. Consumers in these markets prefer their hot pepper to be small or medium sized. The majority of consumers in Miami and New York, have a preference for fresh hot pepper that is mild or hot. The majority of Caucasians and Hispanics prefer fresh hot pepper to be mild, those of Caribbean descent prefer it hot and Asians prefer it to be very hot. Freshness, flavour, appearance and degree of hotness are the most important fresh hot pepper purchase attributes to consumers in these two cities. Consumers in these target markets indicate a strong preference for hot pepper from the Caribbean.

- A positioning strategy that emphasizes the delivery of the above mentioned attributes as well as the authenticity of the product originating from the Caribbean has been

recommended. The direct branding of the product as well as the implicit branding of the food stores that sell fresh Caribbean hot pepper has been proposed to communicate the positioning theme.

Technology Transfer

Technology transfer sessions were held to train farmers in the hot pepper IPM technology. Topics covered in the sessions included: pest identification, fertility management, and principles of IPM. Technology transfer sessions were not only geared at production technology but also demonstrated the benefits of developing a sound marketing strategy i.e. an integrated approach to hot pepper production and marketing. Demonstration plots were used in the technology transfer process.

One major field day was held in Bushy Park, St Catherine September 12, 2000. This was the first in a series of workshops planned to demonstrate IPM systems to key farmers and extension officers in the callaloo growing belts in St Catherine. The theme of the field day was "Integrated Pest Management on callaloo- *Managing the development of insecticide resistance and using alternatives to pesticides*".

A group of 30 agriculturists (key farmers and extension officers of five callaloo districts) comprising callaloo farmers and extension agents were trained in:

1. Integrated Pest Management and how it can be practiced in callaloo production
2. Identification of major callaloo pests and its importance in pest management
3. Using the sampling plan and decision making tool developed for lepidopteran larvae

Networking Activities

Clive Edwards presented a seminar at CARDI Jamaica entitled "The potential of the use of vermicomposting for increasing crop yields and controlling crop pests and diseases."

D. Clarke-Harris, F. D. McDonald planned and coordinated hot pepper meeting with farmers in St Mary to extend improved hot pepper production and increase productivity (August 10, 2000).

Frank McDonald, D. Clarke-Harris participated in the IPM CRSP Annual Planning Workshop, Blacksburg Virginia, in May 17-21, 2000.

Sue Tolin (Site Chair) participated in the IPM CRSP Caribbean Site host country review and planning meetings in March, 2000.

D. Clarke-Harris coordinated and presented a farmer training series - Integrated Pest Management- managing the development of insecticide resistance and using alternatives to pesticides.

D. M. Jackson and J. Lawrence attended the IPM-CRSP Technical Committee Meeting/Year 8 Planning Workshop at Virginia Tech, Blacksburg, VA, May 18-20, 2000.

Sue Tolin, D. M. Jackson, Frank McDonald, D. Clarke-Harris, and K.M. Dalip attended Caribbean Agricultural Technology Conference (CATC), Caribbean Integrated Pest Management Network (CIPMNET), and Caribbean Biosytematics Network (CARINET) meetings, August 17-18, 2000, Kingstown, St. Vincent.

D. M. Jackson and J. R. Bohac served as members of the Sweetpotato Crop Germplasm Committee.

Regionalization of IPM Technology

The major focus of this activity in Year 7 was on the regionalization component. Hence, three Caribbean countries were visited during the reporting period in order to assist sweetpotato farmers in the region to improve the quantity and quality of sweetpotato being produced by initiating the introduction of IPM technologies which have demonstrated potential in Jamaica.

ST KITTS: As a follow-up to the visit to Jamaica in Year 6 by Dr Lilory McComie, Entomologist, CARDI, St Kitts, Ms Janet Lawrence, entomologist and IPM CRSP Site Coordinator at the time, visited St Kitts and Nevis during October 27 and 28, 1999. The purpose of this trip was to observe sweetpotato cropping systems in the islands, to view the work being conducted by Dr McComie and to finalize the work program for 1999 - 2000.

NEVIS: Ms Lawrence visited Nevis on October 27, 1999 and met with the Director of Agriculture and his staff. Field trips to sweetpotato farms were made and information on the crop obtained from farmers and CARDI as well as the Ministry of Agriculture personnel.

ST VINCENT: Ms J. Lawrence had traveled to St Vincent in July 1999 (Year 6) to observe the sweetpotato cropping system in the island and determine the pest composition. On May 08 –11, 2000, Mr F. McDonald and Dr K.M. Dalip made a follow-up visit to St Vincent, mainly to initiate sweetpotato research and to establish linkages with the relevant staff at CARDI and the Ministry of Agriculture**.**

Impacts

The identification of effective and economic management tactics, e.g., use of US and Jamaican sweetpotato breeding lines that are relatively pest-tolerant, is a step towards developing a practical sweetpotato IPM program to reduce infestation by sweetpotato pest populations.

The development of new insect-resistant, dry-flesh sweetpotato varieties with good yield and quality would improve sweetpotato production in Jamaica and other Caribbean nations.

The incorporation of insect-resistant, dry-flesh sweetpotato with good yield and quality varieties in sweetpotato production systems in the Caribbean would improve sweetpotato production of these countries in terms of quality and quantity and hence, increase their competitiveness in the global arena.

Sweetpotato is an important crop for many countries in the Caribbean both as an export product and as a staple of the diet of the local citizenry. Several similarities exist among the islands (Jamaica, St Vincent, St Kitts and Nevis) e.g. pest complex. Under the sweetpotato IPM component, the ultimate goal is to regionalise the technologies developed to reduce pest levels on the crop, such that the quality and quantity of sweetpotato in the Region can be improved and the commodity can become competitive in international markets. Thus, it would be desirable that these problems be tackled collectively in order to accelerate the development and implementation of sweetpotato IPM regionally.

Towards developing a viable and sustainable hot pepper industry in Jamaica, current production technologies from Jamaica and the Eastern Caribbean were successfully introduced into selected parishes in Jamaica. Economic returns from producing hot pepper with the recommended technologies demonstrate that pepper is a lucrative crop for small farmers. IPM CRSP activities are recognized nationally and regionally as the main cog in IPM systems development for hot pepper pests.

The gall midge pest complex on hot pepper is an emergent problem, which is economically important primarily because of the quarantine importance of Contarina species to the US. Deciphering the taxonomy of the species in this complex will greatly assist studies of the biology and behavior of each species. Pest management tactics evaluated could then be based on a better understanding of time and phenological stage of attack by individual species for a more effective timing of intervention

In 1998, high gall midge interceptions crippled the hot pepper industry in Jamaica, resulting in the enforcement of mandatory fumigation as a condition of entry of the product into US markets. This prompted the several responses, many of which were lead by the IPM CRSP team. The development of an IPM strategy to reduce infestations was the focus of the activities and included both pre- and post-harvest investigations. In an initial trial, it was demonstrated that the use of cultural practices in combination fipronyl or imidacloprid suppressed populations of the gall midge complex below a 5% threshold for at least 3 weeks. These results are being used in technology transfer programs being conducted by RADA.

Callaloo production is currently heavily reliant on pesticides because its salability is dependent on the aesthetics of leaves, which are attacked by several voracious herbivorous arthropod species. With the growing concern among consumers globally about pesticide residues on food non-chemical methods of pest control would give a competitive advantage to this commodity.

Exclusion of major pests by using a mesh barrier was demonstrated in earlier trials to be very effective. Other horticultural considerations such as optimal light requirements and the selection of cost-effective screens will provide valuable information for the development of this technology in order to produce callaloo economically in a protected agriculture system.

Synthetic pesticides currently being used on callaloo in the management of major pests, mainly Lepidoptera species fail to give adequate control despite frequent applications. It is unlikely that any developed IPM strategy would exclude the use of pesticides therefore the selection of more effective chemistries is critical to the successful implementation of IPM. Two biorational pesticides used in this trial, viz. spinosad and tebufenozide are registered for use on leafy vegetables and are therefore ready candidates for use with the developed sampling plan and spray application guide.

To date approximately 100 callaloo farmers and extension agents have benefited directly from the training exercises under the IPM CRSP

The interception of pest residues on callaloo stalks presented at pre-clearance facilities for shipment to the United States is a frequent criterion for rejection. Post harvest treatment protocols at packinghouses are not standardized. The commonly used wash solution of common table salt and water is not of a fixed concentration based on empirical data and the mechanism of manual agitation is not very efficient for manipulating the wash load.

The washer basket design allows for improved, uniformed manipulation of the entire wash load and standardization of the process. Appropriate post harvest treatment protocols could reduce pest residues on the product.

ASIAN REGION

Philippines

Sally Miller, Site Chair, Ohio State University
Ronaldo T. Alberto, Site Coordinator, PhilRice

Description of the Collaborative Program

IPM activities in the Philippines site were concentrated in four program areas during Year 7:

1. multi-disciplinary on-farm pest management experiments,
2. multi-disciplinary laboratory, greenhouse and microplot experiments,
3. socioeconomic analysis and training, and
4. IPM technology transfer and feedback.

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

The Philippines site IPM CRSP was successful in Year 6 in obtaining approval for P.L. 480 funds. The 5-year, $ U.S.1.3 million grant entitled "Enhancing the Implementation of IPM to Improve Farmer Competitiveness, Minimize Environmental Risks and Insure Food Security and Safety", will begin in January 2001. The four objectives of the proposal are: 1) Explore and implement IPM technologies and generate new technologies for high-value vegetable crops for reduced pesticide misuse, increased farm product marketability, and farm profitability; 2) Develop transgenic crops for improved vegetable production; 3) Assess economic aspects of improved IPM technologies in rice-vegetable production among small farm units; and 4) Develop training materials and implement season-long vegetable collaborative IPM programs. The principal focus of the P.L. 480 project, which will be seamlessly incorporated into the current IPM CRSP program, is on vegetable IPM in rice-vegetable systems. At the request of the Philippine government, small projects on mango and abaca (Manila hemp) were also included. The latter projects will be carried out in cooperation with other Philippine institutions that specialize in these crops.

The Year 7 workplan was focused on crops, pests and constraints identified in the participatory appraisal process, a structured baseline survey and crop monitoring in years two through four. Planning and collaborative research efforts for the year took place through: discussions among U.S., Philippine and other cooperating scientists at planning meetings in the Philippines, joint host-country/U.S. scientist two-page proposals, a workshop among cooperating scientists to integrate the two page proposals into the overall plan and budget, and revisions to the plan followed by review by the scientists, ME and USAID.

Field research is conducted in six villages in San Jose, Nueva Ecija, in Bongabon, Nueva Ecija, and at the PhilRice experimental farm, also in Nueva Ecija. The host country site coordinator oversees the field research activities. U.S., UPLB, VISCA, IRRI and AVRDC scientists visit the sites periodically to address specific projects. Laboratory and field research is also conducted at AVRDC in Taiwan, and training activities take place at Virginia Tech, Ohio State, Penn State, UPLB and AVRDC.

IPM Constraints Addressed

Key constraints to IPM in the Philippines that were addresses during Year 7 were:

1. absence of economical IPM solutions for specific pest problems,
2. lack of basic understanding of the biology of specific pests,

3. lack of knowledge of sources of germplasm for resistance to insects, pathogens and nematodes, and
4. absence of knowledge about policies, sociocultural beliefs and perceptions, regulations and other factors influencing pest management practices.

Specific major pests being addressed in the IPM program are the root knot nematode (*Meloidogyne graminicola*), bulb rot (*Fusarium* spp.), pink root (*Phoma terrestris*), cutworms and armyworm (*Spodoptera* spp.) and various weeds, particularly *Cyperus rotundus*, in onions. Fruit and shoot borers (*Leucinodes orbinalis*), leafhoppers (*Amrasca biguttula*) and bacterial wilt (*Ralstonia solanacearum*) of eggplant were also addressed.

Selected Research Accomplishments

Descriptions of research progress and results are provided in the individual institution/activity reports. The following are examples of progress and key results obtained in the Philippines site.

- Uncontrolled growth of purple nutsedge in onion can reduce onion yields by up to 90%. Stale seedbed treatments, done once or twice in a one-year rotation cycle, decreased tuber and shoot populations by 80 to 90% at the end of the 2-year rotation period and increased yields by 2 t/ha over those of farmer's practice. Stale seedbed treatments reduced weed control costs and increased net incomes by $1000 over farmer's practice and by $2000 over unweeded plots. Data on tuber and shoot population dynamics of purple nutsedge can be used to develop mechanistic models to serve as a basis for improved weed management strategies applicable to both tropical and temperate conditions.

- Trends in sex pheromone trap catches of male moths indicated that they can be used as a tool for monitoring and surveillance of *Spodoptera litura* for efficient timing of interventions. During the onion season, initial peaks in trap catches and egg mass count of *S. litura* occurred 56 days after transplanting. This is probably the critical time when control measures can be applied. This was followed by peaks in larval population and damaged leaves at 8 and 9 weeks after transplanting, respectively.

- In the rice production regions of the Philippines, rice hulls are commonly burned for disposal. Some farmers in the San José area in central Luzon burn rice hulls on fields after rice harvest and prior to planting vegetables. Our research showed that burning rice hulls ≥15 cm deep reduced incidence and severity of root-knot disease, caused by the nematode *Meloidogyne graminicola*, in the rice-onion system. Increasing thickness of rice hulls from 15 cm to 30 cm deep resulted in increased production of bulbs of export quality (≥ 6.5 cm-diam) and a lower number of 'reject' bulbs. Rice hull burning provided economic benefits to onion farmers.

- Grafting eggplant, using resistant varieties as rootstocks is a very promising approach in managing bacterial wilt of eggplant. Grafted eggplant had the lowest bacterial wilt incidence, which was comparable to that of the highly resistant AVRDC variety Eg 203. No significant differences in bacterial wilt infection were observed in eggplant grown under different cultural practices. The Philippines site is collaborating with the Bangladesh site and AVRDC in developing this technology for eggplant in the Philippines.

- Several eggplant lines, accessions, hybrids and open-pollinated varieties were observed to be resistant to both leafhopper and eggplant borer. Ninety-six eggplant

genotypes were screened for field resistance to the leafhopper at vegetative and reproductive stages and resistance to the eggplant fruit borer at harvest time. These lines will be further evaluated and the most promising ones incorporated into the eggplant breeding program at UPLB.

- Pink root is a serious disease of onions throughout the world, but particularly under the high temperature growing conditions typically found in the Philippines. Nonetheless, there is little information available regarding the level of resistance of commercial onion varieties to this disease under Philippine conditions. The fifteen onion cultivars screened in a field trial in Luzon varied in resistance to the pathogen, with disease incidence ranging from 15 – 33%. This information will be provided to onion farmers to assist them in variety selection.

- Biological control of nematodes and fungal diseases is a challenging task. We identified several biological approaches to disease management with potential for use in Asia and elsewhere. The bacterial antagonist LEP-118 (*Bacillus* sp.) controlled bulb rot and other soil-borne pathogens of onion, and was most effective if applied as a protective coating to the root surface. Vesicular-arbuscular mycorrhizae, *Tagetes* spp. and *Crotolaria* sp. showed great promise for effective and economical management of root knot nematode in onions.

- Numerous variations in morphologic and genetic characteristics between upland and lowland ecotypes of *Cyperus rotundus* (purple nutsedge) may have resulted from the alternate wet and dry regimes over the years that favored the selection of a type of purple nutsedge that can adapt to both upland and lowland conditions. This has significant implications in the management of purple nutsedge, which is the most dominant weed in rice-onion rotation systems.

- NPV-CRSP is a Philippine strain of the nuclear polyhedrosis virus, a potential biological control agent for the onion cutworm *Spodoptera litura.* Semi-purified NPV-CRSP recorded a lower median lethal dose (LD_{50}) of 1.3 x 10^8 PIBs/ml than the NPV Indian strain, with 5.1 x 10^8 PIBs/ml against 6-day old *Spodoptera litura* larvae. Corn starch was the most effective carrier for NPV-CRSP wettable powder. Eight kilos of NPV-CRSP-killed larvae were mass-produced from January-June 2000, portions of which were either formulated into wettable powder or purified and bioassayed against *S. litura* and *Helicoverpa armigera* larvae.

- Social impacts analysis (social variables included income, health and safety, household, social relations, community structure and process, and community resources and support services) revealed that the beneficial impacts of the NPV-CRSP technology far outweighed its few negative implications, which can be reduced and/or easily eliminated. A seminar feedback survey was conducted and results revealed that farmers perceived the NPV technology as beneficial and were all very much interested in joining an NPV training.

- The life cycle of *Meloidogyne graminicola* in onion 'Yellow Granex' was similar to that in rice 'UPL Ri7'. The nematodes entered the roots two days after inoculation and developed into mature females in 14 days in onion and 12 days in rice. The nematode produced about four to five generations per season in 'Yellow Granex'. *Meloidogyne graminicola* significantly reduced bulb diameter of 'Yellow Granex', 'Red Creole', 'Batanes', and 'Tanduyong', as well as the

number of bulbs of Tanduyong. There were no differences in effect between 200 and 10,000 juveniles as initial population level. Older seedlings of Batanes were more resistant to root-knot disease, resulting to heavier bulbs.

- An outbreak of anthracnose of onion, caused by *Colletotrichum gloeosporiodes*, occurred in the San José area during Year 7. Preliminary screening of fungicides, including reduced risk fungicides, revealed fourteen that reduced growth of the test pathogen *in vitro*. Captan 50 WP and Benlate WP were most effective in reducing growth of the fungus, but considerable effects were also observed with Bion MZ 49WP, Dithane M-45, Manzate 200WP and Sweep WP. Kocide 101WP, Funguran OH WP, Previcur N, Vitigran Blue WP, Bion 50 WG and Flint 40WG did not have any effect on the growth inhibition of the pathogen. Identification of the most effective fungicides against anthracnose of onion will help onion farmers in the choosing appropriate fungicides in case of sudden disease outbreak.

Institution Building

Funds were provided for long-term rental of a vehicle for travel to and from research sites. U.S. scientists also provided research supplies during visits to the Philippines site. Research articles were sent from U.S. cooperators, and bibliographies were prepared at Penn State and provided to IPM CRSP scientists. Approximately 50% of the total Philippines site budget was allocated to PhilRice and cooperating institutions in the Philippines. Technology transfer activities of PhilRice, previously devoted exclusively to rice production, were expanded significantly in Year 7 to include vegetable IPM. The addition of P.L. 480 funds will secure the inclusion and expansion of vegetable IPM research in the programs of PhilRice and related institutions.

Human Resource Development

Several students are currently being supported by the project in graduate programs in a collaborating host country university (UPLB) or U.S. institutions. Evelyn Gergon is pursuing a Ph.D. degree in nematology, and Edwin Martin is pursuing an M.S. degree in weed science at UPLB. Jean Recta is pursuing a Ph.D. in statistics at Penn State, and Cesar Mamaril is pursuing an M.S. degree in agricultural economics at Virginia Tech. Madonna C. Casimero completed a Ph.D. in weed science at UPLB during Year 7.

Networking Activities

Networking is accomplished through institutional collaboration between PhilRice, UPLB, VISCA 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. Regional networking was also accomplished by attendance and presentation of papers by IPM CRSP scientists at regional meetings in Asia. Participation during Year 7 include:

- A.M. Baltazar, M.C. Casimero, and S.R. Obien attended and presented papers at the 17th Asian-Pacific Weed Science Society Conference held in Bangkok, Thailand in November 22-29, 1999.
- A.M. Baltazar attended the IPM CRSP Technical Committee Meeting and Year 8 Planning Workshop held at VPISU, Blacksburg, VA on May 18-20, 2000 and the IPM CRSP Annual Research Review and Planning Meetings held in Dhaka, Bangladesh in January 23-28, 2000.
- M.C. Casimero, E.C. Martin, and A.M. Baltazar attended and presented papers at the 31st annual conference of the Pest Management Council of the Philippines held

in Baguio City, Philippines in May 3-5, 2000.

- M. Casimero, won the "Best Paper Award" for her presentation "Morphologic and genetic variations of the lowland ecotypes of purple nutsedge (*C. rotundus* L.) in rainfed rice-onion cropping systems" during the 31st Annual Conference of the Pest Management Council of the Philippines, Bagiuo City, May 2000.
- L. Cuyno presented a paper (from her dissertation "Economic Analysis of Environmental Benefits of Integrated Pest Management: A Philippines Case Study", at the triennial conference of the International Association of Agricultural Economists, Berlin, Germany, August 13-18, 2000.
- N. Opina was a Resource Speaker on the "International Training Course on Plant Breeding," April 3, 2000 at the Institute of Plant Breeding, UPLB and the "International Training Course on Plant-Soil Relationships and Plant Protection" held in IPB, UPLB, College, Laguna on September 15, 2000.
- N. Opina presented the poster "Management of bacterial wilt of eggplant caused by *Ralstonia solanaceraum*" during the 31st annual Scientific Meeting of the Pest Management Council of the Philippines, Baguio City, May 3-6, 2000.
- R. Alberto presented the poster "Cultural management and genetic resistance of bacterial wilt on eggplant" during 13th National Rice Research and Development (R&D) Conference held on March 1-3, 2000 at PhilRice Central Experiment Station, Muñoz, Nueva Ecija.
- M. T. Caasi-Lit presented the poster "Resistance screening of farmers' and commercial varieties of eggplant against the leafhopper, *Amrasca biguttula* (Ishida) during the 23rd Annual Scientific Meeting of the National Academy of Science and Technology. Manila Hotel 5-6 July 2000.
- M. T. Caasi-Lit presented the paper "Eggplant resistance against the leafhopper *Amrasca biguttula* (Ishida) in the Philippines" during a seminar at the Department of Entomology, Kansas State University, Manhattan, Kansas, USA. 14 July 2000.
- G. S. Arida presented the poster "Net barrier for the management of the eggplant fruit and shoot borer *Leucinodes orbonalis* Guenee" during the 13th National Rice R and D meeting. 1-3 May. PhilRice, Muñoz, Nueva Ecija.
- G. S. Arida presented the poster "Larval parasitism of field-collected eggplant fruit and shoot borer" during the 13th National Rice Research and Development meeting. PhilRice, Muñoz, Nueva Ecija.
- E. Gergon presented the poster "Rice hull burning: A farmer's technology for management of root-knot disease in rice-onion cropping system" during the National Academy of Science and Technology Conference, Manila, July 5-6, 2000.
- E. Gergon presented the paper " Root-knot disease in rice-onion system and its management" during the 13th National Rice Research and Development Conference, PhilRice, Muñoz, Nueva Ecija, March 1-3, 2000.
- E. Gergon presented the paper " Management of rice root-knot disease by rice hull burning" during the Pest Management Council of the Philippines Conference, Baguio City, May 3-5, 2000.
- The poster "Molecular detection of *Phoma terrestris* using polymerase chain reaction assay was presented during the 31st Pest Management Council of the Philippines Convention, Baguio City, May 3-6, 2000.
- L. Padua presented the poster " Potential of Nuclear Polyhedrosis Virus (NPV) and *Bacilllus thuringiensis* (Bt) for *Spodoptera* control in yellow granex onions" during the 13th National Rice Research and Development meeting. PhilRice, Muñoz,

Nueva Ecija, March, 2000 and paper with the same title during the 31st Annual Scientific Convention of the Pest Management Council of the Philippines, Baguio City, May 3-6, 2000.

- E. Gergon presented the seminar "Management of root-knot nematode in rice-onion cropping system" to the UPLB Plant Pathology Department, February 16, 2000.
- Tanzo presented the poster "Pest management practices of rice-onion farmers in Nueva Ecija" during the 31st Annual Scientific Convention of the Pest Management Council of the Philippines, Baguio City, May 3-6, 2000.

Technology Transfer

Technology transfer activities were extensive during Year 7. These activities were carried out in cooperation with the Training Division of PhilRice, in both organization of meetings and preparation of training materials for season-long training programs for Provincial and Municipal Agricultural Officers, representatives from Local Government Units and farmer leaders. IPM CRSP scientists were active participants in these training programs; titles of specific presentations are included in project reports. Programs for Year 7 included:

- Season-Long "IPM of Onion" training was planned and conducted in collaboration with the IPM KASAKALIKASAN Program of the Department of Agriculture from November 1999 to February 2000.
- Scientists of IPM CRSP served as resource persons on "Specialized Season-Long Training on Upland Rice-Based Production for Muslim Farmer Leaders and Agricultural Officers" held in PhilRice from July to October, 2000. Training manuals, fact sheets, brochures, one page flyers, flip chart and book marks on a number of diseases and pests of onion and eggplant were prepared, evaluated and disseminated to the participants.
- A half-day activity for 30 farmer-leaders in Palestina, San Jose City was conducted for NPV technology promotion and mass production.
- Research results on field experiments in Bongabon, Nueva Ecija were presented to the members of NOGROCOMA, a national onion growers' cooperative, during their quarterly meeting in Bongabon, Nueva Ecija.

Mutuality of Benefits of the Research

Most of the pest problems addressed in the Philippines site activities 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 methods developed for managing pests of onion and eggplant are particular examples. We are currently cooperating with IPM CRSP Bangladesh and AVRDC through the GDZ-funded Periurban Project in development of eggplant grafting technologies to manage bacterial wilt disease. Economic analyses have shown that strategies such as the use of stale seedbed technology, use of microbial biocontrol agents (NPV-CRSP) in onions, and rice hull burning prior to onion cropping are economically beneficial to farmers in Central Luzon. These strategies are likely to benefit farmers in other Asian countries as well in the near term, and have the potential to be adopted in other regions.

Publications

Selected publications representing the contributions of the IPM CRSP Philippines site to reviewed journals and other venues follow:

- Baltazar, A.M., E.C. Martin, M.C. Casimero, F.V. Bariuan, S.R. Obien, and S.K. De Datta. 2000. Reducing herbicide

use with agronomic practices in onion (*Allium cepa*) grown after rice (*Oryza sativa*). The Philippine Agricultural Scientist 83(1): 34-44.
- Baltazar, A.M., E.C. Martin, M.C. Casimero, F.V. Bariuan, S.R. Obien, and S.K. De Datta. 1999. Weed management strategies in onion grown after rice. Proceedings 17th Asian-Pacific Weed Science Society (APWSS) Conference, Bangkok, Thailand, November 1999, pp. 308-316.
- Baltazar, A.M., E.C. Martin, M.C. Casimero, F.V. Bariuan, S.R. Obien, and S.K. De Datta. 1999. A survey of weeds in rainfed rice-onion cropping systems in Central Luzon, Philippines. Proceedings 17th Asian-Pacific Weed Science Society (APWSS) Conference, Bangkok, Thailand, November 1999, pp 65-70.
- Casimero, M.C. 2000. Population dynamics, growth and control of weeds in rainfed rice-onion cropping systems. Ph.D. Thesis. University of the Philippines Los Baños. College, Laguna. 139 p.
- Casimero, M.C., A.M. Baltazar, J.S. Manuel, S.R. Obien and S.K. De Datta. 1999. Morphologic and genetic variations in upland and lowland ecotypes of purple nutsedge in rainfed rice-onion systems. Proceedings 17th Asian-Pacific Weed Science Society (APWSS) Conference, Bangkok, Thailand, November 1999, pp. 134-139.
- Cuyno, L., G.W. Norton, and A. Rola, "Economic Analysis of Environmental Benefits of Integrated Pest Management: A Philippine Case Study", IPM CRSP working paper 00-2, Virginia Tech, Blacksburg, Virginia, May 2000, 16p.
- Cuyno, L., G.W. Norton, and A. Rola, "Economic Analysis of Environmental Benefits of Integrated Pest Management: A Philippine Case Study", *Agricultural Economics*: Volume 24 (2001): (in press).
- Gapasin, R., M. V. Judal, C. Pile, E. B. Gergon, V. P. Gapud, and S. R. Obien. 1999. Alternative management strategies against the rice root-knot nematode, *Meloidogyne graminicola* in rice-onion system. Philippine Technology Journal 23(2):69-75.
- Gergon, Evelyn. 1999. Diseases in rice-onion cropping systems. Pathologue Newsletter 2:5-6.
- Padua, L. E., V.P. Gapud, E.C. Martin, C.V. Pile, B.A. Santiago, N.S. Talekar, V.F. Recta, E.G. Rajotte and A.C. Lapus. 1999. Use of Nuclear Polyhedrosis Virus (NPV) and *Bacillus thuringiensis* (Bt) for *Spodoptera* Control in Yellow Granex Onions. Philippine Entomologist. 13(2):159-168.

Bangladesh

George Norton, Site Chair, Virginia Tech
Rezaul Karim, Site Coordinator, Horticultural Research Center, BARI

Description of the Collaborative Program

IPM activities in the Bangladesh site were concentrated in three program areas during year 7, which was year 2 for Bangladesh. The first of these areas was analysis of baseline survey data and crop monitoring. The second was multidisciplinary pest management experiments. The third was socioeconomic analyses. The work was conducted as a collaborative effort among scientists at the Bangladesh Agricultural Research Institute (BARI), the Bangladesh Rice Research Institute (BRRI), the Asian Vegetable Research and Development Center (AVRDC), the International Rice Research Institute (IRRI), the University of the Philippines-Los Banos, Penn State University, Purdue University, and Virginia Tech. Rezaul Karim served as site coordinator and George Norton served as site chair.

The Year 7 workplan focused on crops, pests, and constraints identified in the participatory appraisal process the previous year crop-pest monitoring. Planning and collaborative research 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 Year 8 also involved discussion of the plans jointly with scientists working in the Philippine site during the planning workshop at Virginia Tech in May.

Field research is conducted in farmers' fields in Kashimpur, 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 and tomato. Training takes place primarily at U.S. universities and AVRDC. CARE-Bangladesh has participated in the planning but not the research.

IPM Constraints Addressed

The key constraints addressed in Bangladesh in year 7 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 are fruit and shoot borer (*Leucinodes orbinalis*) and bacterial wilt (*Pseudomonas solanacearum*) and other pathogens in eggplant, various weeds in cabbage and eggplant, aphids and diamond back moth in cabbage, and soil borne pathogens such as root knot nematodes (*Meloidogyne* sp) and *Fusarium* in gourds.

Selected Research Accomplishments

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 results:

- Monitoring of crop pests and their natural enemies in rice and especially in vegetables (eggplant, tomato, cabbage, okra, gourds, and yard-long beans) identified the most serious insects, diseases, and weeds in the Gazipur district. The most serious rice insect was green leafhopper, sheath blight was the most serious rice disease, and *Cyperus difformis* the most significant out of many weeds. Fruit and shoot borer (FSB) was the most serious eggplant pest. Aphids were a significant problem in tomato and fruit fly a major pest in gourds. Many other pests and beneficials were identified in each of the crops.

- Of the 270 accessions of eggplant tested for resistance to bacterial wilt, root knot nematode, and fruit and shoot borer, 77 showed high to moderate resistance to FSB and 9 exhibited resistance to jassids under field conditions. In sickbeds infected with bacterial wilt (BW) or root knot nematodes (RKN), 21 exhibited some resistance to BW and 4 to RKN. These results hold promise for developing varieties resistant to all three pests.

- Among tomato varieties tested, 11 were resistant to BW, 16 to yellow leaf curl virus, and 4 had moderate resistance to RKN, the most damaging pests to tomato in Bangladesh.

- Grafting of cultivated eggplants with BW resistant wild eggplant rootstocks was 88.9 to 95% successful. All the grafted eggplants were highly resistant to BW; none of the grafted varieties were infected with BW, while 44 to 100% of the non-grafted eggplants were seriously infected. Similarly, grafting of cultivated tomato plants with a BW resistant eggplant variety was highly

compatible, with more than an 80% grafting success rate. None of the grafted tomato plants were infected with BW, while the non-grafted tomato plants had 16.7 to 25% BW infection.

- A trap with the synthetic pheromone lure, Cuelure combined with Methyl eugenol and Naled, proved most effective in trapping fruit flies in cucurbit crops.

- Results of on-farm experiments in okra and eggplant found that the current number of weedings can be reduced to generate higher net returns.

- Experiments with soil amendments in eggplant found that sawdust burning in the seedbed and incorporation of poultry refuse, mustard-oil cake, and neem oil cake in the field, gave the highest yields. Sawdust burning gave the highest seed germination, and produced taller and healthier seedlings with minimum disease and root-knot nematode infestation. In the eggplant field, plots with poultry refuse, mustard oil-cake and neem oil cake had lowest mortalities of plants from bacterial wilt and fungus infections, lowest infestation of root-knot nematode, and produced maximum yield.

- On-farm experiment at Kashimpur demonstrated that sawdust burning or soil incorporation of mustard oil cake, and poultry refuse in cucumber seed beds can effectively reduce pre-and post-emergence losses of cucumber plants, and produce healthier plants than applying fungicide and nematicides.

- An on-farm experiment was conducted at Kashimpur to determine the effects of soil amendment treatments and applications of nematicides and fungicides for producing healthy bunching onion (*Allium fisturosum*). The results indicated that plots with poultry refuse produced taller, heavier and healthier bunching onion plants with minimum disease infection and nematode infestation compared with those of the farmer practice and control plots. Plots treated with poultry refuse also produced significantly higher yields.

- Blemished vegetables are sold at a 22% lower price at the farm-gate than unblemished vegetables. Insects and diseases are the major causes of blemishes.

- An economic impact assessment procedure was set up for IPM in Bangladesh that draws on GIS and economic surplus analysis models. The models were tested for a soil-borne disease control strategy on eggplant and weed control in cabbage. Results from the tests project several million dollars in net welfare gains given the projected adoption over the next 30 years. For example, it is projected that the reduction in hand-weeding from four to two will generate as much as $26 million in net economic benefits over that time period. Use of neem powder may generate $29 million.

- Research progress and key results for the past year are summarized above. During the first year, a baseline survey was completed and several experiments begun that resulted in the findings described above. In addition, impact assessment work was begun to project aggregate impacts of this research. A PL 480 proposal was also written and submitted to USAID. USAID asked for revisions to the proposal, which will be made and submitted this year.

Institution Building

Equipment, vehicles, and other support

Funds were provided for vehicle repair and rental to facilitate transport to and from research

sites. Computers, copier, supplies, etc were provided.

Research training
One U.S. student, T. Debass, worked on his masters thesis at Virginia Tech (agricultural economics) assessing the economic benefits of the IPM program. One student at Penn State worked on his dissertation research in sociology with a focus on factors influencing IPM adoption in Bangladesh. One Bangladeshi student, C. Mahmoud, worked on his Ph.D program in agricultural economics at Purdue.

Scientist travel
E. Rajotte, G. Luther, G. Norton, and A. Baltazar traveled to Bangladesh in January to review research results and help plan additional research. Shively visited in August to further collaborate with host country scientists on marketing issues as they affect IPM (his graduate student, C. Mahmoud, also went). S.K. DeDatta traveled to Bangladesh in September to review research progress. R. Karim traveled to the United States and Virginia Tech to participate in the IPM CRSP annual workshop and planning meeting and to discuss administrative issues.

Human resource development
A human resource development plan for the next four years was revised that includes both short-term and degree training. A Bangladesh scientist from the project will begin his studies in weed science at UPLB shortly.

Networking Activities

Networking is accomplished through institutional collaboration among BARI, BRRI, UPLB, the Institute of Post Graduate Studies in Bangladesh (IPSA), CARE-Bangladesh, and IRRI-Bangladesh. Both IRRI and AVRDC play key role in networking with other countries in the region. Scientists involved in the project work throughout the region and can spread research results through visits to other countries and participation in workshops, meetings, and other networking activities. U.S. universities also help with networking in the region. Some of the scientists on the project also work with the Philippines site, including the weed scientist from UPLB working in the Bangladesh site.

Mutuality of Benefits of the Research

The pest problems assessed in these studies are widespread throughout Asia and also occur in other parts of the world. IPM approaches to manage these problems have broad applicability, especially in Asia. The consumption of vegetables is 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 with a major country in a politically sensitive area of the world.

EASTERN EUROPEAN REGION

Albania

Doug Pfeiffer, Alternate Site Chair, Virginia Tech
Charlie Pitts, Site Chair, Penn State University
Josef Tedeschini, Site Coordinator, PPI, Durres

Description of the Collaborative Program

IPM research activities in Albania, during 1999-2000 in olive crop has initiated with three major activities:

1. educational/planning activities and crop/pest monitoring,
2. multidisciplinary pest management experiments,
3. socio-economic analyses.

The work was conducted as a collaborative effort among 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 7 work plan focused on the olive crop and its pest management problems. Planning and collaborative research took place through discussions among host country and US scientists at planning meetings in Albania. The research was based on prioritisation developed through a participatory appraisal process and a structured baseline survey.

Field studies were conducted at the experimental station of FTRI and the monitoring activities were performed at several places in the Vlora region. Several laboratory analyses were conducted at FTRI, PPI and AUT.

The host country site coordinator frequently oversaw 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 7 were the need of IPM solutions to specific pest problems in olive crops and the need for information on socio-economic factors influencing adoption of IPM. Specific major pests being addressed during this year in IPM program are olive fruit fly (*Bactrocera oleae*), olive moth (*Prays oleae*), leaf spot disease, olive knot and several weeds.

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:

Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems:

- The IPM CRSP research site for the year 1999-2000 was at the Experimental Station of FTRI (Shamogjin) in the Vlora Region. Field surveys were done for the incidence of insect pests, diseases, nematodes and weeds in olive orchards. For the monitoring of key pests different pheromones were used for the first time in Albania. The population dynamics of olive moth (*P. oleae*) and olive fruit fly (*B. oleae*) were clarified and more information is available to better control the main pests of olive. A new hemipteran pest attacking olive flowers was identified and has initiated the reference collection of new pests and natural enemies of thrips, black scale (*Saissetia oleae*) and olive fruit fly. Four predatory ants were determined and our understanding of the role of natural enemies of black scale in maintaining this pest below the economic threshold level has improved. Parasitism rates by *Scutellista cyanea* (a natural enemy of black scale) were very high in several places.

- Data have been collected to estimate actual fruit damage caused by olive moth. Olive fruit fly infestations have been documented as the predominant insect pest problem impacting olive fruits during the cultivation season. Severe olive fruit fly infestation is generally associated with significant losses especially in early-ripening olive varieties.

Different varieties have shown different levels of infestation. Infestations by the olive psyllid, *Euphyllura olivine* (Psyllidae), were also common. This represents another pest that will be included in our efforts to develop IPM approaches.

- Field monitoring revealed the presence of leaf spot and olive knot as two more important diseases of olive trees in the Vlora district. Monthly observations show that the higher level of leaf spot disease appeared during March-April and the new galls of olive knots became visible during May-June.

- Several species of nematodes were collected infesting olive orchards and olive nurseries. Nematodes determination is underway.

- To develop an effective weed control strategy, measurements of weed density and identification of dominant species was conducted in experimental fields. After data collection the dominant species among woody perennials were *Dittrichia viscose* (L.) W. Greuter and *Rubus ulmifolius* Shott, among the grass species *Agropyrum spp*. L., *Bromus* spp. etc, and among broad-leaved weeds *Soncus asper* L., *Trifolium* spp., *Cirsium arvense* etc. The number of weeds estimated in monitored area varies from 250-300/m^2.

- In general all the data colleted from this year activities will serve to develop models that can be used to forecast pest outbreaks and establish acceptable levels of chemical pesticide use. These will be used as a basis for the development of an IPM system.

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

- Harvest can be timed to maximize increasing yield and minimize olive fruit fly infestation. If growers can select the optimal time to simultaneously maximise yield and minimize olive fruit fly infestation, then possibly chemical control for olive fruit fly can be reduced. To determine the time when these two processes can be balanced, a block with 500 olive trees was selected at the Vlora experimental orchards. This year, harvest date treatments have been selected starting at the beginning of October with biweekly intervals. Increased net returns and decreased use of pesticides is expected from those experiments.

Interactions between Organic Vegetation Management and Insects and Disease:

- Two types of management were evaluated, an organic production system and one using synthetic pesticides and fertilizers (conventional system). Both systems were established in experimental fields of FTRI.

- Satisfactory results have been obtained with the use of mulching straw, including increased productivity of olive trees, decreased weed competition and conservation of soil moisture for longer periods of time. Good results were also obtained using the selective herbicide diuron, reducing weed germination and treatments with the non-selective herbicide glyphosate.

- During the observations no significant differences was seen between the numbers of olive pests in both cropping systems but after the treatment for olive moth, the presence of natural enemies was significantly different. In the organic production system where Bt was used for the first time, the number of natural enemies was higher compared with those in conventional system where the broad-spectrum insecticide dimethoate (Rogor) was applied.

- Regarding olive fruit fly control, different bait treatments are under testing, namely

protein hydrolysate + natural pyrethrum in organic production system and protein hydrolysate + dimethoate in conventional system. Harvest data are pending, since olives are harvested in November.

- New systems for weed management, the reduction of insect populations with pesticides allowed in organic agriculture, the development of new products, organic olives and oil for the export market are the impacts foreseen in this project.

Effect of Pruning on Olive Production, Infestation by Black Scale and the Incidence of Olive Knot and Timing of Copper Sprays to Control Leaf Spot and Olive Knot:

- Three levels of pruning severity (non-pruned, lightly pruned and heavily pruned) were tested. Water sensitive papers attached to branches have demonstrated that the penetration of water droplets was higher in heavily pruned trees and lightly pruning trees relative to non-pruned trees. Spray penetration was improved in trees with more open canopies. Some data indicate that the black scale infestation was reduced in pruning trees.

- Another experiment was carried out applying treatments with copper fungicides every month (October-May) to determine the best moment of spraying to control leaf spot and olive knot. The results of this year to date show that the treatments of March and April are more protective.

- This project will allow greater implementation of a non-chemical tactic and organic-acceptable products into olive IPM.

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

- Olive fruit fly is the main key pest of olive in Albania. Sprays for this species disrupt biological control of black scale. The latter is considered a very damaging olive pest. Because sprays have not been widely used for several years, most groves now have a viable population of scale parasites and predators, a resource of natural control that should be conserved. If a pheromone-based program is successful, fly damage will be minimized without sacrificing biological control of black scale.

- For this reason a study was conducted in Vlora Region in order to determine the effect of a lure and kill system for control of *B. oleae*. In an isolated olive orchard, a lure and kill device treated with deltamethrin to which a long-life pheromone and ammonium salt are added (Eco-Trap sachet produced by Vioril, Greece), is hung within the canopy of each olive tree.

- The Eco Traps were placed at the end of June before first flight of olive fruit fly and again on the first day of September. Fruit damage was assessed every week and the results compared with those where insecticides were applied and with the untreated control.

Socio-Economic Analyses:

- To understand the price and marketing for olives in Albania and other Mediterranean countries a draft-project is under preparation.

- Regarding the other project about Economic Impacts of Albania IPM CRSP Research Activities, surveys were made in several Albanian Regions with the objectives of evaluating economic impacts resulting from pest management strategies on olives developed by the IPM CRSP, and to design a system for assessing impacts in other IPM programs in Albania.

Institution building

Equipment and other support funds were provided to facilitated research activity. Computers, copiers and other supplies were provided.

Scientists travel

C. Pitts, D. Pfeiffer travelled to Albania in October 1999 to start again the activity with Albanian Institutions and helping them to plan the research activity.

D. Pfeiffer returned again in March 2000 to help Albanian scientists in setting up different experimental trials and resolving the financial problems.

M. McGiffen travel during the first week of May to help on setting up the vegetation management experiment.

D. Taylor and Albanian graduate student and faculty member of AUT, L. Daku travelled to Albania during June to evaluate and forecast economic impacts resulting from pest management strategy on olive developed by the IPM CRSP Albania.

L. Ferguson and B. Teviotdale travelled during the last week of August helping to review results of experiments about the main diseases of olive crop and to help in setting up the experiment on effect of harvest timing on olive fruit fly infestation.

Networking Activities

The primary focus of networking has been through workshops conducted by IPM CRSP collaborators. Workshops have been developed at the regional district and community levels. During this year we have been in contact with about 150 farmers, extension officers and olive oil processing producers. All workshops have been supplemented with materials that present performance proven IPM olive pest management strategies.

Albanian specialists have participated and discussed about the IPM in olive crops in two workshops organised by AAATA (Assistance to Albanian Agricultural Trade Association) and AOA (Alimentary Oil Association)

A training activity was initiated to increase the quality of experimental designs and rigor of statistical analyses. US & Albanian scientists developed designs and analyses for the field-based research project. As a results of a participatory workshop Albanian researchers adopted JMP statistical software for rapid data analysis as experiments were conducted.

Four Albanian specialists have attended the 4th International Symposium on Olive Growing, held in Bari, Italy from 25-30 September 2000 and 25th Anniversary Jubilee Meeting of the IOBC-WPRS Working Group "Use of Pheromones and other Semiochemicals in Integrated Control" in Greece, 25 – 29 September 2000.

Mutuality of Benefits of the Research

Benefits to Albania relate to development of IPM practices that are not disruptive to ecological systems or human welfare and will allow Albanian olive products to be competitive in an international market. Benefits to US relates to observation of IPM system in perennial cropping systems under a regime of low pesticides availability. American commodities are facing loss of key pesticide groups and specialists will benefit from working in the Albanian system.

BOARD OF DIRECTORS

The annual IPM CRSP Board of Directors meeting was held at Virginia Tech on 29 - 30 March 2000. Attendees were:

Appointed members:

Ed Kanemasu (Chair; University of Georgia), Robin Huettel (USDA), David Sammons (Purdue University), Aaron Parke (Ministry of Agriculture, Jamaica), S.K. De Datta (Virginia Tech), Tom Mew (International Rice Research Institute), Bobby Moser (Ohio State University), Paul Backman (Penn State University), Ikbal Chowdhury (Lincoln University).

Ex-Officio members:
Brhane Gebrekidan (Program Director, IPM CRSP, Virginia Tech), Greg Luther (Assistant Program Director, IPM CRSP, Virginia Tech), Robert Hedlund (Project Manager, IPM CRSP, USAID).

Technical Committee Representative:
George Norton (Chair of Technical Committee, IPM CRSP, Virginia Tech).

The welcome address by S.K. De Datta (Principal Investigator, IPM CRSP) was entitled, "Leveraging IPM CRSP for Globalization and Institutionalization of IPM." The Board passed a motion to accept the contents of De Datta's speech.

Major decisions made by the Board included:

- There was a consensus that US universities need to elevate international activities to an equal status to other demands on professional time.
- The Board recommended that the External Evaluation Panel be paid their honoraria by the Management Entity immediately upon acceptance of their report by USAID.
- The Board recognizes and appreciates the substantial cost sharing contributions made by host country institutions.
- The budget report was accepted.
- A plan for Board Member rotation was instituted.
- Dr. Moser was elected as the new Board Chair.
- There was a consensus that increasing impact of the IPM CRSP in host countries is very important, and to do this the CRSP needs to link strongly with governmental extension services, NGOs and other extension organizations.
- A new IPM CRSP Training Plan will be instituted. This contains degree and short-term training plans, training to date and future training needs. It will also be used to track IPM CRSP graduates.

Certificates of appreciation were presented to outgoing Board members Tom Payne, Ikbal Chowdhury, Ed Kanemasu, and Santiago Obien.

Minutes of the Board Meeting are available on request from the IPM CRSP ME.

TECHNICAL COMMITTEE

The IPM CRSP Technical Committee (TC) held one conference call as well as its main annual meeting at Virginia Tech in Blacksburg, Virginia, on May 18 - 20, 2000. Technical Committee members for the year were:

Sally Miller, Site Chair, Asian Site in the Philippines

George Norton, TC Chair, and Site Chair, Asian Site in Bangladesh

Mark Erbaugh, Site Chair, African Site in Uganda

Sam Kyamanywa, Host Country Site Coordinator Representative

John Caldwell, Outgoing Site Chair, African Site in Mali

Keith Moore, Incoming Site Chair, African Site in Mali

Sue Tolin, Site Chair, Caribbean Site in Jamaica

Glenn Sullivan, Site Chair, Central American Site in Guatemala
Roger Williams, Outgoing Site Chair, South American Site in Ecuador
Jeff Alwang, Incoming Site Chair, South American Site in Ecuador
Charlie Pitts, Site Chair, Eastern European Site in Albania
Doug Pfeiffer, Alternate Site Chair, Eastern European Site in Albania
Michael Irwin, External TC Member
N.S. Talekar, International Agricultural Research Center Representative
S.K. De Datta, Principal Investigator, IPM CRSP
Brhane Gebrekidan, IPM CRSP Program Director
Greg Luther, IPM CRSP Assistant Program Director
Bob Hedlund, Outgoing IPM CRSP Project Manager, USAID
Harry Rea, Interim IPM CRSP Project Manager, USAID

The minutes for these meetings are available on request from the IPM CRSP ME. In addition to the Technical Committee members, host country coordinators attended the Year 8 Planning Meetings at Virginia Tech.

In its May 2000 meeting the IPM CRSP TC approved the following Summary Criteria for resource allocation across sites: Past productivity or impacts, Potential for future impacts within the host country as well as transferability to other countries, Regional balance, Length of time already supported, and Horticultural export crops at least 50%, Transitional systems at least 35%, and Innovative research at least 15%.

The TC also approved the following budget distribution across sites for Year 8 of the IPM CRSP:

Guatemala	$175,000
Ecuador	$215,000
Jamaica	$130,000
Philippines	$185,000
Bangladesh	$230,000
Mali	$160,000
Uganda	$225,000
Albania	$160,000
Global Themes	$40,000

Other major decisions made by the TC include the following:

- Add a gender specialist to the TC and modify the IPM CRSP guidelines to reflect the change. The gender specialist will be selected from the existing IPM CRSP member institutions.

- Agreed to organize a symposium in May 2001 at Virginia Tech in Blacksburg focusing on Global IPM Themes and designated the following to serve as members of a Global Themes Committee: Mike Irwin (Chair), George Norton, Steve Weller, Sally Miller, Sue Tolin and Brhane Gebrekidan to work on the content and implementation of the symposium as well as the related book on the theme. The book is planned to document the PIPM Global approach and experiences of the IPM CRSP.

- The Global Themes Committee (GTC) with the inputs of two external reviewers evaluated the single proposal received in response to the second call for proposals. The committee decided that the proposal was not fundable because it did not meet the requirements and the guidelines given in the RFP.

- Approved the Year 8 Work Plan of the IPM CRSP and the associated budget as given above.

- The TC confirmed and elected the following as the Executive Committee members of the IPM CRSP for the coming year: George Norton (chair), Glenn Sullivan, Mark Erbaugh, and Sue Tolin.

- The TC also re-elected George Norton as TC Chair.

EXTERNAL EVALUATION PANEL (EEP) REVIEWS

The External Evaluation Panel (EEP) of the IPM CRSP conducted a review in Year 7 at Virginia Tech in Blacksburg, Virginia, June 28-30, 2000. Current members of the EEP are Sonny Ramaswamy, Kansas State University, Chair; Shelley Feldman, Cornell University; Donald Plucknett, Agricultural Research and Development International; Douglas Rouse, University of Wisconsin; and Laurian Unnevehr, University of Illinois. The EEP produced a comprehensive report which is available in full with the Management Entity of the IPM CRSP. The executive summary of the review as well as the main recommendations of the EEP are given below:

Executive Summary of the EEP Report

In the middle of the second phase, the IPM CRSP is maturing into an exciting and productive entity that has encouraged a diverse array of scientists from different disciplines to work together to address issues of importance to increasing agricultural productivity, reducing poverty, and enhancing environmental sustainability. The CRSP is to be commended for leveraging additional funds that have allowed expanding into additional crops and sites. The EEP was impressed with some of the innovative component research developed and the training imparted to students and others.

Despite the significantly low funding, this CRSP has demonstrable outcomes and impacts. The potential for considerably more impacts is tremendous if the CRSP is funded at a level consonant with the number of institutions and scientists involved, and as was promised by USAID when the second phase renewal was approved.

Mature sites such as the Philippines, Guatemala, and Uganda have made significant progress in addressing an array of constraints on diverse crops and in developing component technologies. The newer sites have made a good beginning in addressing pest constraints. The IPM CRSP is at the threshold of taking these technologies and packaging them for use in effectively managing pests on targeted crops. If proven to be effective, these packages should be transferable regionally and globally. While some sites have been more aggressively successful at initiating studies of the sociological and economic impact of the technologies being developed, others have not. The CRSP needs to be vigilant to ensure that the components are integrated into a usable package in light of a critical analysis of the participatory appraisals, lest we be left with a variety of innovative components that are not meaningful either for the integrated management of pests or in the social context.

Summary of EEP Recommendations

- The EEP recommends that the TC and ME re-examine criteria used for funding the individual projects. We recommend the inclusion of past productivity or impacts; global significance and importance of constraint, but with a regional balance and of potential mutual benefit to LDC/US; and the balance for horticultural export crops 50%, transitional systems 35%, and innovative research 15%.

- The CRSP needs to vigorously pursue the opportunity to analyze and interpret the data from the participatory appraisals. Information is needed on which PAs have been successful and which ones have not, and reasons for the same.

- The social science and economic impact analyses need to be imbedded into the biological component and integrated management packages from the perspectives of the intended targets (clientele and stakeholders), how they are to be used, and the eventual beneficiaries.

- The IPM CRSP should begin analysis and interpretation of the PIPM process and data obtained from the various sites, and create an overall theme of its replicability.

- The CRSP should encourage integration of all aspects of the work done, particularly the development of integrated pest management strategies; the EEP recommends the CRSP promote symposia and workshops that are focused on themes of IPM and its component technologies, with debates and discussions of replicability and transferability.

- The Global Themes concept is mandated as a means to push for regionalization and globalization of the strategies and concepts; a recommendation is to use the potential additional funds from AID to solicit comparative, replicated studies across sites within regions or even across regions, thus fostering globalization of the concepts and strategies.

- We encourage eliciting a commitment from the institutions and scientists involved to promote the integration of the programs within institutions.

- The IPM CRSP across all sites has demonstrated low productivity in the area of publications and impact statements. The EEP is concerned that there is not enough effort to wrap up studies and prepare them for publication. The CRSP has to articulate a publication strategy to all of the scientists involved.

- The IPM CRSP has done a reasonably good job of promoting linkages with various groups. However, there is demonstrable lack of an articulated strategy for promoting the acceptance and transfer of IPM strategies by working with NGOs and other organizations, i.e., vertical and horizontal linkages should be promoted to ensure that IPM CRSP leaves a legacy that is not pesticide-centric.

- Workplan format: There needs to be an overall statement from the site coordinator regarding which activities have been completed, which are continuing, and which are new. There should be an overall justification for the status of various activities, and in mature sites there should be strong justification for new activities in terms of furthering global impact.

- The EEP recommends that the CRSP needs to articulate a coherent training strategy, including short-term and long-term training opportunities.

- Some of the sites have proposed development of transgenics to deal with pest constraints. While the EEP recognizes that the CRSP needs to pursue all avenues to deal with pests, it is imperative that the CRSP not expend its valuable and meager resources to “develop” transgenics, but rather to use “off-the-shelf” technologies. The decision should be predicated also based on the current social and economic backlash against GMOs.

TRIP REPORTS, YEAR 7

Trip reports from Year 7 of the IPM CRSP totaled as follows:
Albania: 1, Bangladesh: 5, Ecuador: 2, Guatemala: 1, Jamaica: 3, Mali: 6, Philippines: 3, Uganda: 2. These reports are all posted on the IPM CRSP web site,
http://www.ag.vt.edu/ipmcrsp/

TECHNICAL ASSISTANCE

Management of the Coffee Wilt Disease Epidemic in Uganda: Etiology, Pathogenesis and Epidemiology Studies, 2000 - 2004

In Year 7, the Uganda Site of the IPM CRSP began collaboration with the National Agricultural Research Organization (NARO) of Uganda to address the increasingly important problem of coffee wilt disease in Uganda. This IPM CRSP Technical Assistance project will focus on etiology, pathogenesis and epidemiology of coffee wilt disease (*Fusarium xylarioides* Steyaert).

The goal of the project is to control the epidemic of coffee wilt and restore coffee production in Uganda. The objectives are: (1) To establish the status of coffee wilt disease (CWD) and its impact at farm and national levels and to create awareness among key players and stakeholders regarding disease importance and control; (2) To understand the pathogen, its epidemiology, spread and interactions with the host, environment and cultural practices; (3) To collect, characterize and evaluate coffee germplasms for resistance or tolerance to CWD and develop and disseminate appropriate varieties that are resistant or tolerant to the disease; (4) To develop and deploy effective host plant resistance, cultural, chemical, biological and integrated control methods for controlling the disease epidemic; (5) To rapidly multiply, distribute and transfer CWD control packages to farmers.

This technical assistance project is funded collaboratively by the USAID/Uganda Mission ($75,000) and the IPM CRSP Technical Assistance funds ($75,000).

Publications, Presentations and Other Products of the IPM CRSP

Cumulative Compilation through June 2, 2000

Category	General /	Albania	Bangladesh	Ecuador	Guatemala	Jamaica	Mali	Philippines	Uganda	Total
Papers Published in Refereed	0	0	0	0	3	17	3	7	6	36
or Reviewed Publication										
Books/Book Chapters	0	0	0	0	2	0	0	0	0	2
Theses And Dissertations	0	0	0	1	7	3	2	3	1	17
Proceedings	14	0	0	0	64	14	9	42	16	159
IPM CRSP Annual Reports	8	0	0	0	0	0	0	0	0	8
and Highlights										
IPM CRSP Working Papers	2	2	0	1	3	0	3	7	1	19
World Wide Web Sites	2	0	0	0	0	3	0	0	0	5
and Documents										
Germplasm Releases	0	0	0	0	0	4	0	0	0	4
Papers/Seminars Presented	0	1	0	6	61	27	15	15	48	173
Electronic Presentations	0	0	0	0	0	4	0	0	1	5
Posters	1	0	0	0	3	12	0	9	2	27
Extension Publications	0	0	0	0	4	7	1	2	4	18
Fact Sheets	0	0	0	0	0	1	0	6	4	11
Newsletters	14	0	0	0	0	1	1	0	3	19
Magazine and Newspaper	0	0	0	0	1	0	0	0	0	1
Articles										
Videotapes	0	0	0	0	0	1	2	1	0	4
Workshops	0	0	0	1	0	6	3	3	5	18
Reports	31	7	21	26	141	139	75	111	58	609
Abstracts	0	0	0	0	2	7	1	2	4	16
Bibliographic Databases	0	0	0	0	0	0	0	6	0	6
and Miscellaneous										
TOTAL	**72**	**10**	**21**	**35**	**291**	**246**	**115**	**214**	**153**	**1157**