IPM CRSP
ANNUAL HIGHLIGHTS FOR YEAR 6 (1998 - 1999)

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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Montana State University
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University of Georgia
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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 - PPRI, 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

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IPM CRSP ANNUAL HIGHLIGHTS FOR YEAR 6 (1998 - 1999)

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. As stated in the IPM CRSP Phase II renewal document, 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**.**

Year 6 (September 29, 1998 - September 28, 1999) of the IPM CRSP marks the beginning of the second five year phase. The research activities of the IPM CRSP are based on close collaboration between scientists of the participating host countries and US institutions. The participating host country sites of the CRSP during the year included Albania, Bangladesh, Ecuador, Eritrea, Guatemala, Honduras, Jamaica, Mali, The Philippines, and Uganda. Among the partner US institutions are: University of Georgia, Lincoln University, Montana State University, Ohio State University, Penn State University, Purdue University, U.C.-Davis, 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 6 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. This document gives for each active site in a region, description of the collaborative program, IPM constraints addressed, selected research accomplishments, progress made in training and institution building, and networking activities. The other sections of the report cover several major activities of the CRSP such as Gender Equity, the Board of Directors Meeting, Technical Committee Meetings, External Evaluation Panel Reviews, 1890 Institutions, Trip Reports, Technical Assistance, and Impacts across Regions. Details on each of these topics and other related items can be found in the institutional reports of the Year 6 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 6 were:

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

Africa Site in Eritrea: Asmelash Wolday, Dept. of Agricultural Research and Human Resource Development (DARHRD) of the Ministry of Agriculture (Site Coordinator)

Latin America Site in Ecuador: Roger Williams, Ohio State University (Site Chair), 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), Janet Lawrence, CARDI (Site Coordinator)

Asia Site in Phillippines: Sally Miller, Ohio State University (Site Chair), Victor Gapud, PhilRice (Site Coordinator) E. Tiongco and L. Sebastian, PhilRice (Site Coordinators-elect)

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

Eastern Europe Site in Albania: Charlie Pitts, Penn State University (Site Chair), Doug Pfeiffer, Virginia Tech (Alternate Site Chair)

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.

Jean-Pierre Amirault, Assistant Coordinator, Africa IPM Link, Virginia Tech.

Sally Hamilton, Program Director, Women in International Development, Virginia Tech.

AFRICAN REGION

Mali

Description of the Collaborative Program

The primary focus of the Mali Africa site in Year 6 was participatory on-farm research on IPM technologies for management of diseases and insect pests of the two most important horticultural export crops, green beans and hibiscus. Both economic and gender implications of these technologies were examined in assessing results and research directions. This research was 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. A major new effort was begun to provide support to pesticide residue analysis and develop a Quality Assurance System for Malian horticultural products. Regionalization of phase I technologies developed for pest management in cereals was also carried out.

The on-farm research was conducted in two villages near the capital city of Bamako and within an hour of the airport from which green beans are exported to France. Two sets of trials were conducted, each with five farmers per village: trials comparing IPM practices and farmer insecticides for control of the insect complex on green beans, and trials comparing IPM and farmer practices for control of green bean seedbed diseases. In this first year of 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.

Selected Research Accomplishments

IPM Alternatives for Green Bean Insect Pest Management

Results of on-farm testing for control of the insect complex on green beans showed that IPM management practices combining yellow traps and

targeted application of locally-prepared neem extract reduced populations of thrips (*Megatothrips* sp.) and resulted in yields equivalent to the use of insecticides common in the region. These results confirmed hypotheses established prior to the research. Economic analysis showed the use of yellow traps alone was the most profitable technology for each village and also for the average of the two. The use of yellow traps in controlling insects on green beans was more cost-effective one or two applications of Decis, commonly used by farmers.

Yellow traps had an average net benefit of $4,718 / ha. At average yields of 15 metric tons / hectare, the 600 metric tons of green beans exported to France last year would translate to an estimated 40 hectares of production. The total potential net benefit of this technology is nearly $190,000. The reorientation of the Mali site in phase II of the IPM CRSP is already showing strong potential economic impact.

New IPM Solutions for Green Bean Seedbed Disease Management

The level of disease incidence in on-farm trials for control of green bean seedbed diseases was low in 1998, and IPM treatments did not have effects on seedling emergence, the number of plants per hill, or disease incidence at any location. However, well-decomposed compost resulted in a 26% increase in yield compared to the farmer's compost. Overall, farmers' compost reduced yield 18% relative to the mean yield of other treatments. At the Baguineda research station, yield with farmers' compost was less than half yield of plots which were solarized or treated with a botanical product prepared from the local plant *Longocarpus* spp.

Laboratory research laid groundwork in 1998 for future on-farm testing of additional IPM disease control measures. Soil was collected from several fields in the trial villages, the biocontrol agent *Trichoderma* spp. successfully isolated from these samples, and propagation for inoculation into compost begun. Analysis of farmers' and well decomposed compost were negative for *E. coli*, a potential contaminant of the green beans.

Gender Implications of Green Bean Pest Management

A preliminary survey revealed that men are responsible for the application of insecticide, while mainly women and children do watering. Overall, owners of the farm irrespective of gender carry out production and marketing activities. These findings, if confirmed with a larger sample, suggest that disease management trials need to involve women in assessing the practicality and benefits of changes in water management, while insect management trials may involve men more than women.

Potential Biological Control for Hibiscus Insect Pest Management

Research on potential candidates for biological control on hibiscus insect pests was carried out by IPM CRSP-supported graduate student Moussa Noussourou, as part of an MS thesis at the University of Mali. Prospections of farmers' fields around the Baguineda horticultural station and an observational plot at the Baguineda horticultural station identified 16 above ground entomophagous of insect pests of *dah*. Non-choice feeding studies with 9 predators of *Nisotra* spp. identified three predator species (all Reduviidae) with promising rates of consumption (> 3 *Nisotra* spp. / day).

A New, Innovative Approach to *Striga* Parasitic Weed Management

The innovative approach to *Striga* management at the Mali site involves the use of herbicide as the near-equivalent of a vaccine against the parasitic weed. Provided that the crop have sufficient tolerance to the herbicide to germinate and grow normally while retaining a small amount of herbicide in its system, the parasite attaching itself to this crop will accumulate quantities of the herbicide that result in inhibited parasite growth. Screening of Malian sorghum and millet varieties determine their relative tolerance to the selected herbicides identified 'CSM 388,' a very susceptible to *Striga* parasitization, as most tolerant to herbicide coatings. The herbicide prosulfuron was identified as a promising candidate for effective use for seed treatment.

Enhancement of Pesticide Residue Analysis Capabilities for Quality Assurance

The capabilities of the Environmental Quality Laboratory (EQL) of the Central Veterinary Laboratory were increased, and a comprehensive five year plan to make it functional for a wide range of pesticides was prepared. The plan will create a Quality Assurance Program linking research and education, agriculture and consumers, and economic growth and environmental safety.

Initial collaboration with the EQL begin to build information needed for the Quality Assurance System, and to develop sampling and analysis capabilities for the most critical pesticide residue needs. A list of pesticides used in Mali was prepared. Standard Operating Procedures were developed for sampling soil and water, and for handling and storage of these samples. A workable bioremediation plan was developed for managing laboratory chemical wastes. Initial extractions were performed to analyze DDT in water and to test for deltamethrin in green beans.

In a four-week training program, the director and principal resident scientist of the EQL developed skills in preparation of gas chromotography standards from 6 formulated pesticides; injection of organochlorine and organophosphorus pesticides on a gas chromatograph; calculation of standard dilutions; extraction of green beans fortified with deltamethrin using matrix solid phase dispersion; and extraction of soil samples and calculations of percent recovery from fortified soil samples.

Training and Institution Building

Moussa Noussourou was supported by IPM CRSP for his MS graduate study at the University of Mali. The student successfully defended his thesis, "Identification of Potential Candidates for Biological Control of *Nisotra* spp. on Hibiscus (*Dah*) In Mali," in August 1999. Foster and Caldwell served as outside members of his committee, providing input into the research design and interpretation of results in September 1998 and January 1999. In between and after these trips, Caldwell assisted in literature searches, and Foster assisted with identification of certain predators.

Networking Activities

Two major networking activities occurred this year. First, the IPM CRSP field research team was able to link up with the EQL pesticide residue analysis personnel to merge common goals for decreasing risks from pesticide misuse, pesticide application where other IPM techniques can provide equivalent or better protection, and loss of revenue from not meeting organic standards for exported agricultural products. Second, Drs. Dunkel and Yeboah established linkages with growers, exporters and NGOs in Mali to discuss exchange information on needs related to pesticide residues and agricultural products in Mali.

Bouréma Dembélé visited Virginia Tech from April 2-17, 1999 and James Westwood visited Mali, July 2-12, 1999.

Six graduate and undergraduate students and mentorees with an international focus presented a 3 hour workshop for students and faculty in Montana State University. The workshop was entitled "Adventures in Ethnopharmacology: From Village Elders to Toxicology Laboratory to Commercialization." Results presented included research using neem in integrated pest management systems.

Dr. Gamby and Dr. Georges Ntoukam, entomologist at IRAD (Maroua Research Center), Cameroon presented sessions for farmers and World Vision trainers in San, Mali (March 1999). These sessions included workshops on participatory on-farm research and integrated pest management.

Initiation of Regionalization

Several regionalization activities were carried out for phase I results. A training-of- trainers activity and farmer workshop was held with World Vision in San, in eastern Mali. Participants included farmers, World Vision technicians, agricultural field technicians, and IER scientists. This effort had an inter-CRSP aspect. Results of IPM CRSP research in Mali was presented, while a

demonstration of the construction of solar heaters and triple bagging storage was given by the Bean Cowpea CRSP-Cameroon. Another regionalization effort involved identifying other economic uses of the presses used to prepare neem extract with the manufacturer of the presses, an NGO, and Appropriate Technologies, Inc. (ATI). A poster series was developed to visually convey information about the breadth of use of the products of the neem tree for use in a future interCRSP series on seed protection.

Uganda

Description of the Collaborative Program

The Uganda Site operates under a Memorandum of Understanding with Makerere University Faculty of Agriculture. Dr. S. Kyamanywa, Chairman of the Crop Science Department, continues to serve as the Site Coordinator. He is functionally linked to the Ugandan National Agricultural Research Organization (NARO) through the Deputy Site Coordinator, Dr. G. Bigirwa. The Director General of NARO, Dr. J. Mukiibi, appointed Dr. Bigirwa as the IPM Coordinator for NARO in October 1998. In the recent reorganization of the Ministry of Agriculture and Animal Industries, all technology transfer (extension) activities now fall under the purview of NARO. The IPM CRSP team in Uganda consists of 4 co-PIs and 5 graduate students from the Faculty of Agriculture, 8 co-PIs from NARO and 4 extension agents, representing 8 separate disciplines. In addition, there are 7 USA based co-PIs who work collaboratively with Ugandan counterparts to plan and implement research activities. This multi-institutional and disciplinary program is coordinated by the Site Chair, Dr. Mark Erbaugh at Ohio State University and administered locally by Drs. Kyamanywa and Bigirwa. In addition to the contact between the Site Chair and Coordinators each of the co-PIs are encouraged to maintain communication with their respective collaborators on individual research activities.

The IPM CRSP in Uganda is also working closely with 5 farmer associations, two each at research sites in Iganga and Kumi Districts, and an informal organization of tomato growers located in Mpigi District. Linkages with farmers, a cornerstone of this project, are maintained through on-farm trials, assessment and training activities and through contact with extension agents. This mode of operation has provided Ugandan research scientists with valuable on-farm experience and successfully raised their visibility in the rural areas.

IPM CRSP research efforts in Uganda are planned through a series of steps that seek to maximize institutional and farmer collaboration. An initial workshop was held on December 7-8, 1998, in Jinja, Uganda, with Ugandan co-PIs from Faculty of Agriculture, Makerere University, the National Agricultural Research Organization (NARO) and the Ministry of Agriculture and Animal Industries' Extension Service to discuss progress and problems with the previous seasons' research activity implementation. This meeting also provided an opportunity to reassess and build upon the priorities originally established through the farmer participatory appraisal process, baseline survey, and farmer field pest monitoring activities. This on-going process of prioritization, evaluation and team building was aided by a visit to Uganda in December 1998 from Dr. S. Ramaswamy, a member of the IPM CRSP External Evaluation Panel (EEP). Co-PIs were then charged with discussing research plans for the upcoming season with collaborating farmer NGO groups and with USA based co- PIs. In early March another meeting of the IPM CRSP Uganda Site co-PIs and 3 USA based co-PIs was held in Mbale, Uganda to present brief progress reports, discuss priorities, and to develop draft work plans for Year 7. This draft work plan was then presented and discussed with Drs. Mukiibi, Director General NARO, and Sabiiti, Dean, Faculty of Agriculture, and Mr. R. Stryker, USAID/Kampala, before being presented by the Site Chair, Site Coordinator and Deputy Site Coordinator at the IPM CRSP Annual Meeting held at Purdue University in May, 1999. Another management component added this year was a Research Reporting Workshop held in

Mbale, Uganda, in late August 1999. At this meeting 15 research papers prepared by co-PIs and graduate students were presented and critiqued. It is hoped that this workshop will fulfill the request and promise contained in the External Evaluator's report: "Everyone of the players involved in the (Uganda Site) IPM CRSP appears to be in synch, supporting each other's research activities to the extent that significant returns are expected".

The planning and implementation of IPM CRSP activities in Uganda also involves co-PI communication and collaboration with the local USAID Mission, the International Center for Insect Physiology and Ecology (ICIPE), the Rockefeller Foundation through the Makerere University Legume Improvement Program, germplasm exchanges with 3 IARCs including IITA, CIAT and CIP and the founding of a Grey leaf spot collaborative network that includes several IPM CRSP USA and Ugandan co- PIs, CIMMYT/Harare, Rockefeller Foundation and several Universities in South Africa. Collaborative activities with ICIPE and the Rockefeller Foundation have provided opportunities to cost-share several graduate student training programs at Makerere University.

IPM Constraints Addressed

The primary constraint to IPM adoption in Uganda is the lack of proven alternatives to multiple applications of chemical pesticides, particularly for important legume crops in Eastern Uganda, but also for newly added horticultural crops. The capacity of the Ugandan research system to develop IPM alternatives has been historically impeded by research fragmentation among the various institutions and by weak links between research scientists and farmers. During the initial participatory assessment and the later baseline survey farmers indicated a strong dependence on and use of multiple sprays to control pests and diseases on cowpea and groundnuts. Research efforts by the IPM CRSP have developed agronomic, and reduced spray alternatives for these crops, and, in the case of groundnuts have popularized a disease resistant variety. The presentation of research results by 15 co-PIs and graduate students in August demonstrated progress towards the development of IPM technologies for most priority crops. Another constraint is the lack of data on incidence and severity of pests and diseases. Farmer field pest monitoring results provided important documentation of the unrecognized importance of bean fly as a critical pest on beans. A survey of maize diseases demonstrated the importance of gray leaf spot. Remaining constraints are to sustain research momentum, to broaden impacts, and, to convince key policy makers that IPM is economically and socially viable. These constraints are intertwined, and require a redoubling of effort to document, disseminate and publish results. The recently completed follow-up assessment will help provide some of this information but greater attention needs to be applied to economic evaluations of IPM technologies. Several of these efforts have potential for impact in the United States. Perhaps the best example from the Uganda Site is the work being done on identifying genetic resistance to gray leaf spot, the number one foliar disease of maize in Uganda and in the US Corn Belt.

Selected Research Accomplishments

- Field trials with cowpea in Eastern Uganda established that the major diseases were viral (Cowpea mosaic virus), scab (*Sphaceloma* sp.), yellow blister (*Synchytrium dolichi* (Cooke), cercospora leaf spot (*Cercospora cruenta* and *C. canescens*) and powdery mildew (*Erysiphe polygoni* DC). The major insect pests were pod sucking bugs (*Riptortus* spp., *Nezara viridula*, *Acanthomia* spp. and *Anoplocnemis* sp.) and *Maruca* sp. and Blister beetle (*Mylabris* spp.). Trial treatments included effect of plant density, planting date and minimal pesticide application on disease severity and pest infestation. Trials indicated that a spacing of 60 x 20 cm. and planting at the on-set of rains significantly reduced disease severity and insect pest infestation. In addition, the minimum spray schedule consisting of two insecticide spray applications (as compared to the farmers'

practice of using six applications) resulted in the highest yield and income.

- *Striga* parasitism of sorghum can be minimized by using an integrated striga management strategy consisting of a striga tolerant sorghum variety, Seredo, modest fertilizer application, two hand weedings and interplanting with *Celosia argentia*, locally known as *Striga* chaser. Results indicate that use of a resistant/tolerant sorghum variety coupled with moderate dose of nitrogen (80kgN/ha) and weeding twice is the best approach to reduce the level of *Striga* attack and increase sorghum yield. Interplanting sorghum with *C. argentia* is an affordable alternative when farmers cannot employ use of improved varieties and fertilizer. The impact of interplanting sorghum with cowpea compared with interplanting with *C. argentia* on *Striga* emergence was not significantly different. However, the cowpea intercrop reduced sorghum yield while *C. argentia* increased yield. This is explained by the cowpea growth habit of climbing the sorghum thus reducing sorghum height.

- Development of an integrated disease and pest management package for groundnuts indicated that the improved variety *Igola-1* was more resistant to rosette disease and Cercospora leaf spot compared to the two unimproved local cultivars despite the recording of high aphid populations. Thus, the resistance of *Igola-1* is directed to the virus and not the aphid vector. Close plant spacings recorded higher incidences and severities of leaf spot but lower rosette incidences and severities. Therefore the medium plant spacing of 45 x 15 cm along with the *Igola-1* variety is recommended to control both diseases. Plant spacing had a significant effect on reducing aphid infestation but no significant effect on root rot and thrips infestation.

- *Chilo partellus* was found to be the predominant stem borer species in Eastern Uganda on maize and sorghum, and in importance is has surpassed *Busseola fusca* in Iganga District. Yield losses caused by stem borers on maize in Iganga were found to range between 212 and 440 Kg/ha. Intercropping maize with beans offers moderate levels of control on stem borer infestations. *Cotesia sesamiae* was the most common local parasitoid found. The introduced parasitoid, *Cotesia flavipes*, multiplied and released in a collaborative activity between the IPM CRSP and ICIPE, has been established and causes parasitism of up to 23% in Iganga and 18% in Kumi on *C. partellus*.

- Seed dressing to control bean fly (*Ophiomyia* sp.) and root rots *(Fusarium solani* and *Fusarium phaseoli*) increased bean grain yields by 75%-156%. Diazinon was as effective in reducing bean fly damage as Endosulfan. Use of the fungicide Benlate as a seed dressing was not as effective in controlling root rots as use of Endosulfan supporting other observations that root rot infection is related to bean fly incidence. The impact of seed dressing is more pronounced under drought stress conditions. Earthing-up at first weeding reduced bean fly damage and increased grain yield between 32%-35%. The practice of earthing-up is recommended for small-scale bean production. Over 100 farmers near research sites in Iganga have been exposed to the practice of seed dressing and earthing-up through a combination of on-farm trials, farmer open-days, and the development and distribution of fact sheets.

- Treatments testing the efficacy of selected biorationals, solarization and a synthetic insecticide to control damage by bruchids (*Acanthoscelides obtectus* and *Callosobruchus* spp.) found that beans admixed with Mexican marigold (*Tagetes* spp.) and *L. camara* dust had the highest bean damage level whereas beans mixed with tobacco dust had the lowest damage level. The performance of tobacco, Actellic, ash and solarization in reducing bean bruchid damage did not differ significantly. The most effective treatments for cowpea

included solarization, and admixing with tephrosia and tobacco. Unlike in beans, solarization method did not affect cowpea seed germination/viability. Farmers in seven districts (Iganga, Kumi, Soroti, Katakwi, Lira, Apac, and Mpigi) have adopted solarization and admixing beans with tobacco leaf powder; and solarization and admixing of cowpeas with tephrosia or tobacco leaf powders.

- Tomato growers ranked late blight *(Phytophthora infestans*) and bacterial wilt (*Ralstonia solanacearum*) as their most important disease problems during a participatory assessment held with growers in Mpigi District, March 1999. The PA also established that most farmers sprayed their tomatoes twice a week throughout the growing season. First season on-farm disease surveillance and pest-monitoring trials indicated that late blight was the most prevalent disease and thrips (*Megolurothrips sjostedti* (Trybom)) the most prevalent insect pest. Three tomato clones tolerant to bacterial wilt were identified and introduced into on-farm trials. Farmers have already taken seed from these trials for use in their own fields. First season on-station trials on alternative methods to control late blight provides preliminary evidence that transplanting seedlings into a cover crop (Sirato) may provide protection by spores spread by rain splash on soil.

- Longe-1, a commercial open pollinated variety demonstrated more resistance to maize streak virus than local varieties and out yielded local varieties. Intercropping did not significantly reduce maize streak disease incidence.

- The profitability of growing maize as a monocrop versus intercropping with beans was evaluated using partial budgeting. The most profitable practice was to grow the improved and streak resistant maize variety Longe-1 in a monoculture providing the highest net cash benefit with an added return of USD 257/ha compared to the local maize monocrop with an added net return of USD 107/ha compared to intercropping with beans. The local maize monocrop yielded the lowest net benefit of about USD 10/ha compared to its intercrop. Intercropped Longe-1 added USD 159 in net returns per ha compared to the local maize intercrop.

- Yield loss assessments derived from on-farm trials demonstrated that the prevailing yield loss due to stalk borers on a total stand basis was only 3%. If the same criterion is applied to the level of foliar stand injury observed by farmers, the prevailing yield loss on a total stand basis would be 2%. In general, farmer observations of pest activity on maize demonstrated that termites are a more significant problem than stalk borer. As a result, IPM CRSP activities on maize have shifted to a greater programmatic emphasis on termites than on stalk borer.

- An important result of the farmer field pest monitoring program has been farmer training for their subsequent participation with on-farm trial experiments. Farmers participating in the process of collecting crop monitoring data become familiar with the importance of sampling procedures, record keeping, and develop an awareness of the systematic process required to participate in agricultural research. Since an important goal of participatory agricultural research is to empower farmers to learn, adapt, and to become active investigators, the contribution of this model program should be recognized.

- Gray leaf spot (*Cercospora zeae-maydis*) resistant germplasm was identified with acceptable agronomic performance in both Ohio and Uganda. Breeding efforts to utilise disease resistance of tropical germplasm were successful and cooperative evaluations revealed suitable agronomic performance across temperate and tropical environments when breeding lines were testcrossed with temperate maize inbred testers.

- A follow-up baseline questionnaire to obtain information on pests, pest management practices and socio-economic factors associated with knowledge, awareness and practice of IPM was administered to 200 farmers in Iganga and Kumi Districts in Uganda. Preliminary data analyses indicate that 63% of the respondents are using pesticides on field crops. Pesticide usage is more common in Kumi than in Iganga district. Among the IPM CRSP focal crops that include maize, beans, groundnuts, sorghum, and cowpea, the most commonly sprayed crops are cowpea and groundnuts. In both districts, men are more likely than women to purchase and apply pesticides. However, within the household, women are commonly involved with pest management decisions.

- Fifteen advanced potato clones with diverse backgrounds were screened for resistance/tolerance to bacterial wilt, one of the most serious diseases of potatoes worldwide and in Uganda. Five of the 15 genotypes, evaluated on the principle performance indicators of yield, plant survival, minimum rotting tendency and number of plants that survive till maturity, appear to be promising. The clones in order of performance are: 388575.9, 390854.11, 388575.5, 390018.3 and 388574.6. Future selection will involve tuber and culinary characteristics along with the initiation of intercropping trials.

Institution Building

The IPM CRSP's emphasis on process, including research planning and farmer participation, and the locally recognized need to advance multi-institutional and disciplinary research have been recognized by several administrators as a key contribution of the IPM CRSP to agricultural research in Uganda. Another indicator of IPM's institutionalization is the creation of a new department of Crop Protection at Makerere University. Dean Sabiiti gives partial attribution to the IPM CRSP for stimulating the demand for this department.

Four Ugandan graduate students have made substantial contributions to on-farm data collection and to IPM CRSP activities as a whole. In a recent conference at Makerere where 38 graduate students from the Faculty of Agriculture presented their research findings, two IPM CRSP graduate students placed first and third in a competition for best presentation. The graduate student training being done by Makerere University was another aspect of Uganda Site activities commended in the external evaluation report. Dr. George Bigirwa spent several weeks with Dr. R. Pratt, at the Ohio Research and Development Center entering and analyzing data from their survey of maize diseases. This collaboration has resulted in three papers being presented at the All African Crop Science Society meetings.

There were 8 trips made to the Uganda Site this year by USA based co-PIs. In addition Mr. Tom Debass, graduate student from Virginia Tech joined Drs. Erbaugh, Warren and Bhagsari to participate in the work plan development meeting, training of baseline enumerators program; and to collect data for his Masters thesis. Drs. Erbaugh, Gebrekidan and Luther also participated in the research results conference held in August. Drs. Pratt and Willson made individual trips to pursue their collaborative research activities.

Networking

In-country networking between the two primary agricultural research institutions in Uganda is promoted by the functional links between the Site and Deputy Site Coordinators, who remain in close contact through their respective heads, the Director General of NARO, and the Dean of the Faculty of Agriculture at Makerere. The Site Coordinator always ensures that USA based scientists make a courtesy visit with both the DG and the Dean and the Site Chair always meets with these two gentlemen to update them on progress and to seek their support on various issues that arise. Additionally, the composition of the Uganda team includes scientists from all the major research institutes in the country including Kwanda, Naumulonge, Serere and Kabanyolo research institutes. Also, meetings are regularly

held and updates are provided to USAID/Kampala and the technical assistance personnel attached to the primary agricultural project in Uganda, the IDEA Project. As a result of his IPM CRSP involvement, Dr. Kyamanywa was invited to participate in a USAID consultancy which examined the USAID/Uganda Agricultural Sector Pesticide Procedures Guidelines and, Dr. Willson was asked to make contributions to the Quick Reference Guide for Crop Chemicals being produced by the IDEA Project.

Regional networking takes the form of communication, participation and occasional collaboration with other organizations and professional societies. Drs. Pratt and Erbaugh presented IPM CRSP acknowledged papers at the recent meetings of the All African Crop Science Society meetings held in Casablanca, Morocco, as did 2 Uganda co-PIs and 4 Makerere graduate students. The IPM CRSP was the only CRSP represented at this meeting. Drs. Erbaugh and Caldwell, Site Chair for Mali, presented papers at the 15th International Symposium of the Association for Farming Systems Research-Extension held in Pretoria, South Africa. Again, the IPM CRSP was the only CRSP represented at this meeting. ICIPE has cost shared the training of a graduate student with IPM CRSP, and Dr. Charles Omwega from ICIPE, participated in Mbale Workshop where research results were presented. The Site Chair and Coordinator also held discussions with Dr. K. Gallagher, Assistant Director, of the Global IPM Facility, an entity initiating farmer field schools in Uganda and other countries in East Africa. Networking also continues with the Rockefeller Foundation. Joint activities with the Rockefeller Foundation occur via the Makerere University Grain Legume Program. Most recently, at the meeting in Morocco, the Grey Leaf Spot Network for East and Southern Africa was established with important inputs from Dr. Pratt and leadership provided by IPM CRSP co-PI Dr. Adipala. At the organizational meeting the IPM CRSP's pioneering work in this area was acknowledge. Finally, the Africa IPM-Link continues to provide a network for dialogue across the continent on issues pertaining to IPM.

Eritrea

The IPM CRSP activities involve the participation of the Eritrean Department of Agricultural Research and Human Resource Development (DARHRD) of the Ministry of Agriculture, Virginia Tech, and Ohio State University. The program was initiated through the financial support of the USAID Mission in Eritrea through the USAID Global Bureau. The initial funds were allocated for an intensive training program for researchers, extension and development agents, and lead farmers. The training program was successfully completed as planned and yet the allocated funds were not exhausted. These balance of training funds were used to initiate the collaborative research program presented here.

Research was carried out on the following topics: monitoring, survey, and assessment of insect and disease incidence and severity on farmers' fields; integrated S*triga* management trial; evaluation of introduced sorghum varieties for S*triga* resistance; assessment of advanced sorghum varieties for diseases and insects; study and identification of races of fungi; monitoring seasonal activity of adult stem borer populations utilizing pheromone traps.

Selected Accomplishments

Striga infestation was considerably reduced when sorghum received integrated management (inter-cropped with soybean, applied nitrogen fertilizer, and hand weeded twice) as compared to the check plot. The application of appropriate S*triga* management practice reduced the S*triga* weed population by 95 % and increased grain yield of sorghum by 46 % and additional legume yield of 117kg/ha was obtained. Integrated management practice improved sorghum production both by depressing S*triga* and increased sorghum grain yield through the appropriate growing media being provided.

- In the trial of screening highland sorghum cultivars for their resistance against S*triga* all the varieties were infested with the parasitic weed. Although the yield of all the treatments

could not be obtained, the relative resistance of the treatments could be observed by the number of S*triga* plants emerged in each cultivar. IS-29415 sustained relatively fewer S*triga* than others.

- In the trial of screening lowland sorghum cultivars for their resistance against S*triga*, the S*triga* count during the early growth stage of sorghum was very few in number, but the number of S*triga* increased greatly during late season when the crop was already well established to cause reduction of sorghum grain yield. Varieties with entry numbers as P8579 and P8568 were with no S*triga.*

- In the stalk borer trials, variety IS-25557 had one of the highest stalk borer infestations, however, but Amal the local variety had less stalk borer infestation.

IPM Electronic Communication in Africa: Africa IPM Link

The main goal of Africa IPM Link (AIL) is the promotion and use of Information & Communication Technologies (ICTs) in Africa for IPM and related topics. The AIL activities were partially supported by funds originating from USAID AFR/SD office but received through the Global Bureau of USAID. Hence the activities have been implemented as an integral part of the IPM CRSP.

The principal objectives of AIL are to provide electronic networking opportunities for African IPM practitioners, to initiate and promote electronic discussions among professionals with interest on IPM related issues in and on Africa, to update content and improve the IPM CRSP and Africa IPM Link web sites, and to provide training opportunities for African IPM practitioners in the effective use of e-mail and the WWW for IPM information sharing.

Selected Accomplishments

- **Email-based Discussion List, Afrik-IPM**: The main purpose of the Afrik-IPM discussion list is to provide IPM practitioners in sub-Saharan Africa with a networking tool for quick, inexpensive, and effective IPM information exchange. The discussion list has been well established and is operating actively and effectively. In the past year, list "membership" has increased from 61 to 104, representing a wide range of organizations and individuals from 29 countries, including 18 African countries.

- **Africa IPM Link Web Site** (http://www.cals.vt.edu/ail/index.html): The bilingual Africa IPM Link web site was redesigned for easier navigation and a local search engine was added. English and French content was regularly updated; the site currently contains links to over 200 English IPM sites, 100 French IPM sites, and some useful Information & Communication Technology (ICT) sites. Information from the site is routinely accessed from several African countries by IPM practitioners.

- **IPM CRSP Web Site** (http://www.cals.vt.edu/ipmcrsp/index.html): The IPM CRSP web site was redesigned in November 1998. Trip reports, working papers, newsletters, annual report/workshop abstracts, and other IPM CRSP products were posted as they were submitted to or produced by the IPM CRSP Management Entity. Next addition to the IPM CRSP web site will be a discussion forum to allow for easy exchange of information and ideas between all IPM CRSP Co-PIs .

- **IPM Communications Strengthening**: Regional institutions have been identified as partners but funds were not secured for the organization of a bilingual IPM Communications Workshop for West/Central Africa based on the model of the Nairobi workshop of March 1998. Efforts are now being focussed on linking with existing

IPM/sustainable agriculture organizations, commodity/research networks, and other planned initiatives in Africa to provide capacity building sessions for small groups of people on the use of Email and the Internet. The first of such sessions is anticipated to take place during PAN-Africa's regional workshop on IPM and Sustainable Agriculture to be held in Thiès, Senegal, in May, 2000.

- **Assist in Providing Internet/Email Connectivity**: Start-up funds for the purchase of a modem and six months worth of Email connectivity were provided to the headquarters of the Desert Locust Control Organization / Eastern Africa (DLCO/EA) in Ethiopia. In Guinea, the Assistant Coordinator of AIL facilitated a meeting between the director of Entraide Universitaire pour le Développement (EUPD-Guinée), a national NGO umbrella organization, and the coordinator of PAN-Africa with the purpose to secure funding for one-year Email connections for two or three Guinean NGOs through a PAN-Africa/AfricaLink regional NGO connectivity activity.

- **Linkages**: Active electronic linkages have been maintained with international, regional, and national organizations, as well as NGOs. During the year, new strong linkages were formed with NGOs and the National Directorate of Agriculture in Guinea. Linkages were also made with RADHORT, a horticulture network in Francophone West Africa.

LATIN AMERICAN REGION

Guatemala / Honduras

Description of the Collaborative Program

The 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 del Valle, serves as the regional site coordinator for Central America. The Regional Site Committee is comprised of Dr. Sánchez, Ing. Luis Calderón (ICTA), Juan Enrique Leal (AGRILAB), Luis Alvarez (ARF/AGEXPRONT), Rafael Solorzano (ALTERTEC), Eddy Diaz/Victor Salguero (MAGA), Luis Caniz (APHIS-IS), Dr. 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, Stephen C. Weller, C. Richard Edwards, and Ray Martyn (Purdue University) and Dr. Sarah Hamilton (Virginia Tech). The overall Central American site activities in Year Six were funded through IPM CRSP core funds from the USAID Global Bureau under subcontract with Virginia Tech, and grant funds generated from the Government of Guatemala (GOG), FONAPAZ, and ARF/AGEXPRONT.

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

APHIS and ARF/AGEXPRONT continued to provide strong collaborations in the development of IPM / ICM strategies for reducing pesticide use and improving the performances for achieving safer food supplies in the NTAE sector. APHIS-IS continued to provide collaborative leadership in the development of pre-inspection programs in Guatemala. ICTA has collaborated in testing and revising IPM CRSP production strategies for

improved pest management in snow peas (leaf miner), tomatoes (white fly), and broccoli (*Plutella xylostella*). ESTUDIO 1360, in collaboration with Dr. Sarah Hamilton (Virginia Tech) contributed substantively to research activities that evaluated the socioeconomic impacts of NTAE production at the community and household levels.

Research collaborations with FONAPAZ were strengthened in Year Six. FONAPAZ 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. FONAPAZ grants to the IPM CRSP researchers at Univ. del Valle provided funds for community level technology transfer activities, including field demonstrations.

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. 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

Public and private sector policies significantly influence NTAE development in Central America, including the implementation of performance-proven IPM / ICM practices and certified pre-inspection programs. In Guatemala, the private sector has led the initiative for policy revision. AGEXPRONT has reorganized their overall committee structure in a serious effort to develop more proactive policies that will enhance performances in the NTAE sector. Science-based production and pre-inspection policies that lead to reduced pesticide usage and decreased product rejections at U.S. ports-of-entry are now a major focus of AGEXPRONT's policy revision initiatives. Similarly, private sector firms like Tierra Fria and Frutesa have established aggressive proactive policy revisions in their operating performances in a serious effort to enhance their competitive position in the NTAE sector.

On the other hand, government initiatives to revise policies commensurate with the needs of a more competitive marketplace in the NTAE sector have been slow to develop, and currently represent a serious impediment to Guatemala's future performance capacity in international and/or regional markets for NTAE crops. The research and technology transfers of performance-proven IPM / ICM production and post-harvest practices advanced by the IPM CRSP have been frustrated by the lack of timely and response-effective policy initiatives at the central government level.

The timely implementation of performance-proven IPM CRSP production and post-harvest handling strategies continue to be a constraint. Again, the lack of timely and response-effective support from government is an important factor delaying these transfers. ICTA has not yet been given an administrative mandate and/or funding to provide the GOG leadership effectuating such technology transfers, and no other GOG entity, other than FONAPAZ, is positioned to assume such a leadership role. As a result, too many small independent NTAE producers still rely heavily on agrochemical sales agents and unregistered pesticides for their disease and insect pest control information. This constraint will gradually be overcome as more IPM CRSP approved pest management information is transferred through regional workshops, seminars, and field demonstrations, and as the private sector struggles to overcome the gaps left by the government's slow response. However, the private sector alone cannot provide the resources needed to reverse Guatemala's gradual decline in competitiveness in the international marketplace. Recent IPM CRSP market competitiveness assessments indicate that Guatemala is now the 15th most competitive external supplier of vegetables for export to the

USA, a decline from the 5th most competitive position in 1992.

A primary constraint to IPM program adoption in Central America in past years has centered on the research capacity within the collaborating institutions and among the individual collaborators. Many of the collaborating institutions / collaborators simply have lacked the scientific capacity to bring science-based solutions to current pest management problems. While we have made significant progress in resolving this constraint over the last two years, much remains to be done in Guatemala and Honduras. Research is now more focused relative to our overall IPM CRSP objectives and missions, and is presented in a more scientific manner. Dr. G. Sánchez, the IPM CRSP Site Coordinator and plant pathologist trained in the United States, is well founded in science-based research and has been extremely successful in helping raise the level of scientific approach to current research activities among collaborators. Sánchez's leadership in this important area, combined with Universidad del Valle, Purdue University, and Virginia Tech collaborations, and with AGEXPRONT's restructuring and science-based focus, have combined to help enhance the scientific rigor of IPM CRSP research in Guatemala.

Selected Research Accomplishments

- The premier accomplishment in Year Six centers on further development and formalization of the pre-inspection program for snow peas in Guatemala. 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 region, the need for a program that controls the product's quality at the point-of-origin is accepted by a progressive group of snow pea growers and exporters. AGEXPRONT has been instrumental in helping focus the private sector attention on pre-inspection. It is through this group that a voluntary pre-inspection pilot program was established in the 1998-1999 growing seasons and further finalized for the 1999-2000 seasons. 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. Under the leadership of the IPM CRSP, the pre-inspection program was tested in the 1998-99 growing seasons with the participation of several key collaborators. Seven major NTAE packers/exporters agreed to participate in this effort, their combined output accounting for approximately 30%-40% of the country's total snow pea exports.

- Future 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 these non-economic constrains and a decline in Guatemala's competitive position in the U.S. vegetable market. In 1992, Guatemala was ranked 5th among all countries supplying fresh vegetables to the United States and 8th among countries supplying fresh fruit, other than bananas, to the United States. But in 1997, Guatemala was ranked only 12th among fresh vegetable suppliers. The NTAE sector is very competitive, and the more successful competitors seem to have adopted a more "market-driven" focus. Our research suggests that given its relative economic competitiveness, Guatemala could be the 5th or 6th largest supplier of fresh vegetables to the United States with full implementation of a certified pre-inspection program. The IPM CRSP is playing a pivotal role in helping reestablish regional competitiveness in the NTAE sector.

- The technology transfers associated with these activities (pre-inspection) significantly impacted NTAE crop producers by helping reduce pesticide use to acceptable and sustainable levels. Snow pea producers participating in the IPM CRSP integrated pest management / integrated crop management programs reduced pesticide applications from 13 to 4 in each snow pea cropping cycle, while increasing product quality and marketable yields to 12,600 lbs. per menzana (approximately 18,000 lbs. per hectare). This level of performance translates to about $2916 per acre in gross revenue, or about $895 per acre net return to management and family labor. This level of performance is approximately 35% above the average, helping assure economic and socioeconomic sustainability at the small farm household level.

- Overall, IPM CRSP sponsored research documentation and training at twelve regionally dispersed community sites, comparing performance-proven IPM / ICM practices to traditional snow pea production practices, resulted in 25 to 50 percent higher average marketable yields with 75 percent fewer pesticide applications for IPM CRSP developed management strategies.

- More importantly, performance-proven IPM / ICM strategies for tomatoes have allowed the reintroduction of tomato production into regions that were no longer being cultivated because of severe white fly – geminivirus problems. The implementation of IPM CRSP developed strategies for control of white flies in tomatoes has enabled several regions in Eastern Guatemala (Sanarate, San Agustin Acasaguastlán and Retana Valley) to reestablish high value fresh market tomato production. Research in tomato has shown that use of the IPM CRSP developed 22 point program for control of white fly and its associated gemni-virus can reduce the number of needed insecticide sprays from 30 to 12, and greatly improve grower profits.

- The significance of the aforementioned IPM CRSP research accomplishments in Central America were highlighted in the inaugural issue of *Sustainable Development International: Strategies and Technologies for Local and Global Agenda 21 Implementation* (an entity created by 174 heads of state at the United Nation's Rio Summit in 1992). The paper titled "Sustainable Development in Central America's Non-Traditional Export Crops Sector Through Adoption of Integrated Pest Management Practices: Guatemala Case Study" was published and is summarized as follows: Non-traditional crops for export (NTAE's) have played an increasingly important role in Central America's economic development since 1983. This relatively new market-driven development opportunity has represented the fastest expanding sector of the agricultural industries in Central America, with an average annual growth rate of 16 percent between 1983 and 1997. However, future development of economically sustainable expansion in NTAE crops in Central America will be substantially influenced by the region's capacity to meet more demanding food safety standards in the United States and Europe. Market access in these countries is increasingly being determined by sanitary and phytosanitary standards, and not solely by economic competitiveness at the production level. Case studies in Guatemala found that chemical overuse was the primary factor contributing to high detentions and rejection rates for NTAE shipments at ports-of-entry in the United States. It was found that producers who adopted performance-proven integrated pest management practices had significantly fewer sanitary and phytosanitary compliance problems. Further, these producers achieved higher marketable yields at lower production costs, resulting in greater economic and socioeconomic sustainability.

- The Central American IPM CRSP was recognized in Year Six by the Association for International Agriculture and Rural

Development (AIARD), Washington, D.C. as one of three exemplary case studies of international development that benefits both the United States and foreign host countries.

- ICM research was elevated in Year Six IPM CRSP activities. ICM (integrated crop management) focuses on the combining of integrated pest management, intercropping, and strip-cropping techniques to achieve a holistic production management strategy that significantly reduces pesticide use, increases marketable product yields and quality, and achieves greater economic, environmental, and socioeconomic sustainability at the small producer and community levels. The integration of these techniques were found to increase marketable yields in snow peas by an average of 25 percent, while reducing pesticide use to only 3 to 4 applications per cropping cycle. The full significance of this research will be determined in Year Seven, but preliminary results are extremely encouraging.

- The institutionalization of IPM CRSP performance-proven production strategies in snow pea, broccoli, tomatoes, and sugar snaps realized a quantum leap forward in Year Six. The "foundation" research in the development of pre-inspection protocols, combined with the aforementioned ICM research, captured the attention of private sector entities, resulting in widespread adoption of IPM CRSP pest management strategies in Guatemala. Led by AGEXPRONT and FONAPAZ, it is estimated that over 50 percent of Guatemala's current commercial snow pea production in 1999/2000 will be managed under IPM CRSP developed pest management strategies. This conversion to more sustainable production strategies will help assure the transfer to other NTAE crops, and provide the basis for the revision and institutionalization of GOG policies that are sorely needed to support this new production paradigm throughout the region.

- Research focusing on the use of entomopathogenic fungi and entomophagous nematodes for control of white grub in broccoli was advanced in Year Six through collaborations with ICTA. Research also continued on parasitoids for the control of leaf miner in snow pea. The parasitoid research on white grub control was inconclusive, but the potential for ectoparasitoid *Diglyphus* in the control of leaf miner was found to be quite promising. Parasitoids have a potentially promising role to play in a fully integrated pest management strategy. Concurrent research has found that once sustainable pest management strategies are implemented for at least three cropping cycles in snow peas, the natural parasitoid populations begin to reestablish. Therefore, the role of a massive parasitoid breeding program may prove not to be economically justifiable. But, this research clearly has helped IPM CRSP researchers understand the role natural enemies play in a balanced and sustainable production regime.

- Socioeconomic research findings completed in Year Six enabled collaborators to establish baseline models for measuring NTAE/IPM adoption impacts at the small farmer household and community levels. These research findings will be used to develop and initiate a comprehensive quantitative assessment of socioeconomic and economic impacts from NTAE cropping regimes in Year Seven.

Institution Building

The Government of Guatemala has strongly supported the IPM CRSP's overall objectives for strengthening scientific capacity and market-focused planning in the NTAE sector. Institutional linkages with the Ministry's of Finance and Agriculture, FONAPAZ, and ICTA have been important factors in moving the IMP CRSP research and development agenda forward in Central America. In addition, institutional collaborations with APHIS-IS, FAS, and AGEXPRONT have been critically important in helping bring additional program funding and focus to the IPM CRSP. APHIS-IS has been instrumental in helping move the pre-inspection

program forward in the NTAE sector. FAS has teamed with the GOG (Ministries of Finance and Agriculture) to provide additional funding for the IPM CRSP Guatemala workplan activities. AGEXPRONT has been instrumental in providing additional research funds and in the transfers of performance-proven IPM CRSP pest management strategies.

The leadership role that was established between Purdue University and Universidad del Valle and Dr. G. Sánchez has helped strengthen the scientific research capacity of collaborating institutions in Guatemala, as well as, that of collaborating researchers and student training programs. The Universidad del Valle has an excellent reputation in the science areas, and has the human resources to play an ever increasing role in the institutional strengthening objectives of IPM CRSP. In recognition of the role that Dr. Sánchez and Universidad del Valle have played in the IPM CRSP, Purdue University awarded Dr. Sánchez an Adjunct Professorship in Year Six. In this appointment, Dr. Sánchez has full rights given to Full Professors at Purdue University with respect to serving on graduate student and research committees, electronic access to the Purdue University system, publication rights, etc.

Efforts continued in Year Six to strengthen institutional collaborations with Zamorano and Fundacion Hondureña de Investigacion Agricola (FHIA) of Honduras. However, progress has been slow with the departure of Drs. Zeiss and Hruska, and the impact of Hurricane Mitch. These efforts will continue in Year Seven through collaborations with Dr. Maria Mercedes Doyle at Zamorano and Dr. Dale Krigsvold at FHIA.

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 collaborated with individuals to strengthen their capacity in research and technology transfer.

Student Training

The human resource development initiatives in Central America focus on five areas: (1) greater student training at U.S. institutions and/or in collaboration with U.S. scientists, (2) NGO training and technology transfer through national and regional workshops, (3) capstone research (thesis) training in collaboration with ZAMORANO and the Universidad del Valle, (4) continued strengthening of the research capacity of host country collaborators, and (5) research training that emphasizes less reliance on pesticides and improved food safety/quality to achieve expanded market opportunities in the NTAE sector. The following students were trained during the year through the IPM CRSP.

Phillip Lamport, a native Guatemalan, completed his Master of Science Degree under the direction of Dr. Stephen Weller and C. Richard Edwards at Purdue University. His thesis title was "Development of IPM Techniques for the Control of Pea Leaf Miner *Liriomyza huidobrensis* (Blanchard) on Snow Peas, *Pisum sativum* L.." His research led to a new and extremely effective trap crop system, using faba beans as a border planting to reduce leaf miner damage in snow pea. The result was a significant reduction in the use of pesticide applications and higher marketable yields.

Jim Julian, a U.S. citizen, finished his Master's Degree in marketing under the direction of Dr. Glenn H. Sullivan at Purdue University. His thesis titled "An Assessment of the Value and Importance of Quality Assurance Policies and Procedures to the Guatemalan Snow Pea Trade" has been instrumental in helping move the public and private sectors towards finalization of a formal pre-inspection program, as the findings clearly quantified the benefits of quality assurance to enhancement of market performance in NTAE crops.

Carlos Mayen, a native Guatemalan and undergraduate student in his senior year at Universidad del Valle, spent the 1999 summer term at Purdue University working on IPM field research with Drs. Stephen Weller and C. Richard

Edwards. Carlos will return to Purdue in July 2000 to pursue a Master of Science Degree under the direction of Dr. Weller.

Victor Hernandez, a native Guatemalan, completed his Ing. Agronomy thesis at Universidad Rafael Landívar titled "Intercropping Impacts on Control of Leaf Miner in Snow Peas". This research was conducted under the direction of Dr. Sánchez.

Sergio Torres, native Guatemalan, achieved partial fulfillment of his research for his Ing. Agronomy degree at San Carlos University testing the resistance of various snow pea cultivars to leaf miner infestation. This research was conducted in collaboration with ICTA under the direction of Ing. Luis Calderón.

Margarita Palmieri and Laura Vergara, both of Guatemala, completed an eight week training session at the University of Georgia under the direction of Dr. Wayne Parrot and assistance from Dr. Sánchez at Universidad del Valle in molecular biology techniques. This research will be instrumental in furthering the IPM CRSP work for the detection and evaluation of papaya ringspot potyvirus. This research training is being used in the tissue culture labs at Universidad del Valle in an effort to help solve the devastating effects of ringspot damage in papaya orchards throughout Central America. This research was partially funded by the Guatemalan National Science and Technology Council.

Brenda Tevalán, a native Guatemala, and a member of the Estudio 1360 staff directed by Dr. Linda Asturias received her licenciatura degree in Anthropology from the Universidad del Valle with a thesis titled "La división del trabajo por género en la producción agrícola de Santa María Cauqué durante la segunda mitad del siglo XX." This research focused on the socioeconomic dynamics of NTAE crop production at the small family farm level.

Networking

Workshops have been developed at the regional, district, and community levels. This activity has been expanded in Year Six with funding from FONAPAZ. The regional workshops have focused on technology transfers to NGO's and independent private sector technicians, while district and community workshops and IPM demonstration research have focused on small NTAE producers in collaboration with ICTA. All workshops and demonstration research have been supplemented with published research materials and user manuals that present performance proven IPM pest management strategies.

Collaborations with APHIS-IS in the development and testing of pilot pre-inspection programs have helped further expand the IPM CRSP networking activities in Year Six. 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 9,500 small farm producers, field technicians, and community leaders throughout Guatemala in our Year's Five and Six workplan activities.

Initial programs collaborations were explored with UTZ SAMAJ in Tecpán, Chimaltenango, Guatemala to develop an IPM / ICM technology transfer program for small NTAE producers throughout the central highlands. UTZ SAMAJ recently received a grant to achieve the transfer of IPM / ICM technology through community level program collaborations, and IPM CRSP was contacted to help achieve the overall program objectives, as the IPM CRSP already has established collaborations in over 56 communities throughout the region.

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 participants in the 1999 AGRITRADE Conference. Participation in this program has led to further discussion on IPM CRSP regionalization with Nicaragua and El Salvador.

Finally, the IPM CRSP held a series of discussion with the Ministry of Agriculture in Guatemala (MAGA) seeking to strengthen program collaborations through greater participation in the development of research priorities and workplan activities. These discussions were still in process at the end of Year Six. It is likely that these discussions will generate a positive result early in Year Seven of the IPM CRSP, after the new GOG administration assumes office.

Ecuador

Description of the Collaborative Program

This is the second year of activity at the South American Site/Ecuador. A total of 8 regular activities and two special projects were conducted. 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 currently serves as the Site Coordinator of the Sierra (higher elevations). He is located at the INIAP Experimental Station at Santa Catalina near Quito and coordinates activities with potato and Andean fruits. Carmen Suárez currently serves as Site Coordinator for the Littoral (lower elevations). She is a researcher at the INIAP Tropical Experimental Station at Pichilingue near Quevedo and coordinates activities with plátano (plantain or cooking banana). Cooperation between the two Site Coordinators facilitates institutional communications and collaborations. Each Activity (research project) has a leader that is responsible for interactions with their respective coordinators and cooperators.

Activities in Year 6, second year for the South American Site, were funded primarily through USAID IPM CRSP and collaborating institutions: INIAP, PROEXANT, CIP, FORTIPAPA and the U.S. Universities that are involved. Even though research activities at the South American site are relatively recent, we are developing collaborative ties with several local organizations which are well established in Ecuador: CIP (Centro Internacional de la Papa), FORTIPAPA, PROEXANT, and an Inter-CRSP with the SOILS CRSP. Through student employees and especially graduate students we are also developing collaborative ties with the local Universities. Jointly developed collaborative research plans have allowed us to buy into ongoing research programs and initiate new projects with joint funding. This approach has been used with the three primary crop areas on which research was initiated (plantain, potato and Andean fruits), and has been particularly effective in Year 6. Since trained personnel were already on board, we were able to take advantage of their skills to conduct collaborative investigations. This system will allow us to provide deliverables at a much faster pace.

IPM Constraints Addressed

The South American Site/Ecuador is addressing some of the known production constraints of some key horticultural staples in the area. Late blight of potato is a worldwide limiting factor in potato production. In Ecuador we have been selecting resistant potato clones with horizontal (durable) resistance. Activities in clonal selection are currently underway, and several lines have been selected for use in future research activities. 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. We feel that great strides are being made in this area. 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. Disease and pest problems of plantains are thought to be similar to those of bananas. A survey of pests and diseases is helping define the critical research needs of this crop as

are research activities and evaluation of various IPM practices for use in plantain.

Substantial progress in the use of safer compounds for the control of insects has been made. Research on the use of biorationals to control the Andean potato weevil has given rise to two potential candidates. Laboratory and field studies have confirmed the efficacy of Spinosad and Naturalis-L. They both are biorational insecticides, which may have important roles in the future control of the Andean potato weevil. Research during year 6 has led us to do more detailed investigations with Spinosad. It has been found to be a useful IPM tool to potato farmers. These are both new compounds which represent a major step in pesticide safety to humans and the environment.

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 that we are aware of. Unfortunately the pesticide safety manuals being developed by the Ministry in cooperation with IPM CRSP have not been developed.

Selected Research Accomplishments

Even though this is a new site, at which funding actually begun in March 1998, we have been able to make some significant accomplishments.

- Through working with researchers that were involved in related work and by collaborating with established agencies, great strides have been made in the control of the Andean potato weevil by finding effective biorational insecticide that replace some of the traditional, more toxic materials.

- Several studies on Andean fruits have been centered around the major mite and disease problems of babaco (Mountain Papaya) and surveys have been conducted to determine the organisms involved. *Fusarium* vascular wilt is the most important disease. It can kill up to 100% of the plants in a commercial orchard. Control of *Fusarium* has been under investigation and the most effective treatments have been identified.

- Mite control strategies for babaco in the greenhouse have shown that their are several effective materials available. One of the most effective compounds was a botanical soap.

- We have defined the dosage and application timing for the control of the Andean potato weevil.

- We have demonstrated that the Central American Tuber Moth can be controlled with a virus (biological agent) originally found in the region. In addition, *Bacillus thuringiensis* is effective in controlling the moth.

- 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.

- Farmer field schools are being conducted, and will enhance our abilities to introduce integrated crop management practices emphasizing control of the Andean potato weevil.

- The survey conducted on plantain has provided information that will aid in the biological control of important insect pests through natural enemies.

Mutuality of Benefits of the Research

The results of 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 are long term resistant 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.

Institution Building
We have been able to supply INIAP researchers with some of the new biorationals that are being approved by EPA for food crops use in the U.S. Two of these have been tested and appear to have promise in the control of the Andean potato weevil. This is a case where only a small amount of foliage is treated and put under a cardboard and this acts as a trap, which is capable of controlling the weevil.

Several Ecuadorian undergraduate and graduate students are presently being funded through various activities of the IPM CRSP for their Independent Study theses and their MS theses from Ecuadorian Universities. This system is helping the CRSP and the Universities to get research accomplished and to train individuals in applied agricultural research.

One of our researchers on the Andean fruit project has taken a short course on diseases at Turrialba Research Center in Costa Rica.

Our student-training plan is to use as many Ecuadorian students as possible in country in conducting the various activities. In addition, plans have been made to allow two junior researchers have research internships in the US beginning in the summer/fall of 2000. They are presently studying English. We are hopeful a third candidate, a senior researcher, will start on his Ph.D. at Ohio State in 2000.

Networking
We conducted our first one-day Mini Workshop on October 23, 1998. This workshop reviewed results for the first year activities and also reviewed plans for the second year activities (Yr. 6) which began September 29, 1999. Over 30 people including most of the investigators of the IPM CRSP from Ecuador and US universities attended this Workshop. We were fortunate to have Bob Hedlund, USAID Project Manager, and two representatives from the INIAP administration and several visitors from other agencies in attendance. We plan to make this an annual meeting which will gradually grow into a larger forum to include students, researchers, extension workers, agricultural buyers and suppliers.

CARIBBEAN REGION

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 1998-1999 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), Ohio State University (OSU), United States Department of Agriculture - Vegetable Laboratory (USDA-VL) and Lincoln University (LU).

Key components have been identified to form the framework of an IPM model for the management of major pests on callaloo. Validation studies of the field chart designed in year five to guide pest management decisions have been completed and have shown the potential to reduce the frequency of pesticide application by up to 60% without significant increase in pest damage and economic loss due to lepidoptera species. The use of the sampling plan has been demonstrated to over 60 farmers within the major callaloo-growing parish of St Catherine. Some farmers had the opportunity to compare callaloo which had received 11 applications based on the calendar

sprayed system with those sprayed six times using the sampling plan. Unanimously the farmers thought the sampling plan plot was either less damaged or had the same level of damage as the weekly sprayed plants.

Selected Research Accomplishments

Pests Affecting Hot Pepper, C*apsicum chinense*

A breeding program to transfer southern root-knot nematode resistance from Scotch Bonnet pepper into Habanero pepper was continued; the third backcross was completed and resistant plants from this backcross are being used to complete the fourth backcross. A breeding program was initiated to transfer southern root-knot nematode resistance from Scotch Bonnet pepper into West Indies Red; the initial F1 cross was completed and F1 plants are currently being backcrossed to the West Indies Red parent. The resistance to the peanut root-knot nematode (*Meloidogyne arenaria* Race 1) in *C. chinense* was found to be conditioned by a single dominant gene; this finding confirms the results of the inheritance study conducted in 1998. The results of growth chamber tests confirmed earlier findings that resistance to southern root-knot nematodes (*M. incognita*) in *C. chinense* is partially compromised at high temperatures. However, the root galling response and nematode reproduction in the resistant Scotch Bonnet germplasm at high temperatures was significantly lower than in susceptible Habanero-type peppers. Root-knot resistant *C. chinense* cultivars should be a useful component of cropping systems designed to manage *M. incognita* in hot climates. The results of a second year of field tests conducted cooperatively with a CARDI investigator in St. Kitts confirmed that the recently released *C. chinense* germplasm lines PA-353, PA-398, and PA-426 are resistant to indigenous field populations of *Meloidogyne* spp.

Seven legumes (velvetbean, Iron-Clay cowpea, sunnhemp, soybean, Cahaba vetch, crimson clover, and hairy vetch) selected for their potential usefulness as cover-crop mulches for weed control in pepper plantings were evaluated for host suitability to southern root-knot nematodes; the velvetbean, Iron-clay cowpea, sunnhemp, and soybean entries were highly resistant and are potentially useful for managing *M. incognita* if used as a cover-crop mulch for weed control.

Viruses are a major constraint to hot pepper production in Jamaica. During the past year, studies were conducted to determine the dynamics of the aphid vectors, the epidemiology and evaluate the potential of stylet oil and cultural practices to reduce virus incidence. Over twenty species of aphids were identified throughout the time of sampling, with the period of greatest species diversity occurring during December 1998 to April 1999. The spread of TEV was slower in plants sprayed with stylet oil than unsprayed plants. 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 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 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. During the past 12 months, a monitoring system that includes the assessment of larval infestation in fruits was developed. This methodology was used to assess populations in IPM studies that evaluated the potential of cultural practices and chemical insecticides to reduce gall midge infestations. The use of cultural practices in combination with selective chemicals fipronyl (Regent ®) and imidacloprid (Admire®) suppressed populations of the gall midge for over 3 weeks below a 5% threshold. These results are being used in technology transfer programs being conducted by the task force.

IPM of Pests Affecting Sweetpotato, *Ipomoea batatas*

A new insect pest attacking sweetpotatoes in Jamaica was identified as the sweetpotato leaf beetle (*Typophorus viridicyaneus* Crotch), and a scoring system for assessing the damage to sweetpotato roots caused by this insect was refined. Sweetpotato IPM component research focused on developing high yielding, red-skinned, cream-fleshed sweetpotato cultivars with resistances to root-knot nematodes, diseases, and insects. In addition, the integration of these varieties with a selective low toxic compound, fipronyl was initiated. Several USDA-developed sweetpotato clones and Caribbean varieties demonstrated good resistance to the sweetpotato leaf beetles, sweetpotato weevils, and/or the WDS soil insect complex in a replicated field test in Jamaica. The regionalization of the sweetpotato IPM was one of the highlights of the component. Researcher exchanges and visits to Jamaica, St Kitts and Nevis, St Vincent, Montserrat and St Lucia provided the medium to initiate sweetpotato research and has set the stage for future expansion of the IPM CRSP research activities.

Pesticide Use, Residues, and Resistance

The goal of this topic is to assess 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. Thus, the activities described below attempt 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.

Over the past three years, results of market basket surveys have demonstrated that pesticide residues are present on marketable produce. In an effort to address the problem. IPM technologies geared at reducing spay applications were developed. To further demonstrate the benefits of these technologies, samples of callaloo from a field experiment which compared routine farmer spraying with a limited pesticide spraying regime were analyzed for pesticide residues.

Policy, Social and Gender-related Issues that Affect IPM Adoption

The primary activity of Year 6 was the analysis of data collected during Year 5's baseline socioeconomic survey in three communities, each affiliated with the IPM CRSP for one target crop and each located in a distinct ecological zone and geo-political region. The goals of this activity were to identify (1) socioeconomic constraints to IPM adoption and (2) beliefs and practices that contribute to health and environmental problems associated with pesticide use.

Among the gender equity issues addressed is whether the adoption of IPM is likely to alter the gendered division of labor and resources within households in ways that would disadvantage women. Findings indicate that IPM adoption would not disadvantage women. However, the potential benefits of IPM adoption may not be as available to women as to men, as women are less likely to receive relevant technical assistance or to be involved in technology development. Gender bias in technology design and delivery may also constrain adoption by households.

Results of a probability-sample household survey in three IPM CRSP research communities showed that women produce and market targeted crops, choose among pest management alternatives, and select and purchase pesticides; as women appear to have less access than men to IPM-related extension, it is recommended that the CRSP intensify efforts to incorporate women farmers in field research activities and to disseminate gender-disaggregated information to extension officers.

At the beginning of Year 6, information had been collected on government policies potentially affecting IPM adoption in Jamaica. Information had been collected on the effects of IPM on costs and returns for callaloo, sweet potato, and sweet pepper. General information had been collected for vegetable production costs and returns for farmers in Ebony Park, Clarendon, Jamaica. A modeling framework was developed for

evaluating returns from IPM adoption for producers of callaloo, hot pepper, and sweet potato in Jamaica. Research findings indicated that the IPM systems developed for callaloo, hot pepper, and sweet potato are potentially profitable. The systems remain more profitable than conventional systems when 1) assumed chemical savings from IPM are eliminated; and 2) labor requirements for IPM are increased by 50%. When the assumed yield increase with IPM was reduced from 30% to 5% for the crops, IPM continued to be more profitable at Ebony Park but not at Bushy Park.

The policies evaluated included pre-clearance of vegetables for export, elimination of water subsidies, elimination of credit subsidies, a reduction in the real interest rate, elimination of the duty concession, a lowering of the Common External Tariff, and an appreciation of the real exchange rate. None of the policies had large effects on the returns to IPM adoption. Policies designed to liberalize the domestic economy are not likely to affect the potential for IPM adoption in sweet potato, callaloo, and hot pepper in Jamaica.

Networking Activities

US and host country scientists active in the Caribbean participated in the IPM CRSP Annual Planning Workshop, West Lafayette, in May 7 - 8, 1999.

D. Clarke-Harris coordinated and presented a farmer training series - Integrated Pest Management- Monitoring Populations of Major Pests on Callaloo, Management of Pests in Callaloo and also attended a CARINET workshop on Identification of whiteflies and mealybugs, Trinidad, W I.

Janet Lawrence, Phillip Chung and Don McGlashan along with other members served as the national the task force on gall midge. A national strategy was developed by the task force and CARDI was given the responsibility to coordinate the compilation of the proposal. This proposal was submitted to the IPM CRSP for funding.

F. McDonald, J. Lawrence, and D. Clarke-Harris helped to coordinate a workshop "Integrated Commodity Approach to the Development of the Hot Pepper Industry". St Mary, Jamaica (November 1998).

D. Clarke-Harris, F. D. McDonald, and J. L. Lawrence planned and coordinated hot pepper stake holders meeting "Development of marketing strategies for the hot pepper industry in Jamaica and the wider Caribbean". Kingston, Jamaica (October 23, 1999).

A number of the IPM CRSP researchers both from the US and Jamaica attended the Caribbean Planning Workshop – Year 6 and beyond at USDA vegetable lab, Charleston, June 28 - 29, 1999; presented summary of research results and recommendations.

Training and Capacity Building

Gary Schlosser and Tina Schlosser, graduate students in the Department of Geography at Virginia Tech, have published results in their Masters theses, which can be downloaded at http://www.vt.edu.

S. McDonald; Ph.D. student at VPI conducted research on hot pepper in Jamaica during the past year. She visited the Division of Plant Industry, Florida Department of Agricultural and Consumer Services in Gainesville to be trained in aphid identification by Dr. Susan Halbert, a Homopterist. (March 21st – 28th, 1999).

Joe Ogrodowczyk, project graduate student, visited the Jamaica site from November 14 to November 28, 1998 to collect data at Bushy Park, St. Catherine, and also to exchange information with CARDI scientists collaborating on the project, and to interview government officials and policy analysts.

D. Clarke-Harris disseminated callaloo pest management guides to farmers, extension agents and researchers in Jamaica. Copies of the publication were also distributed to collaborators in the Caribbean Region.

ASIAN REGION

Philippines

Description of the Collaborative Program

IPM activities in the Philippines site were concentrated in four program areas during Year 6:

(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

Work on two special projects was continued in Year 6: (1) Eggplant resistance to leafhoppers and eggplant borer, and (2) Interaction effects of fungal pathogens and nematodes on pink root and bulb rot severity in onion.

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

The Year 6 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:

(a) discussions among U.S., Philippine and other cooperating scientists at planning meetings in the Philippines,
(b) joint host-country/U.S. scientist two-page proposals,
(c) a workshop among cooperating scientists to integrate the two page proposals into the overall plan and budget, and
(d) 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 6 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, (*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.

- In rice-onion cropping systems the cost of farmer's weed control practices can be reduced by 50% from one herbicide application followed by three hand weedings to one herbicide application and one hand weeding

without reducing weed control efficacy and onion yields. This results in a net added benefit of P22,386 ($1 US = P38) per hectare compared to the traditional farmer's practice.

- Scale-up of the microbial biocontrol agent NPV-CRSP was completed resulting in production of 9 Kg of a wettable powder formulation for use in field experiments to control onion cutworm.

- *Helicoverpa armigera* emerged as a new pest of onion in both Bongabon and Palestina sites for the 1999 dry season. The combined larval densities of *S. litura* and *H. armigera* did not differ among the treatments but were significantly different from the untreated control plots in both Bongabon and San Jose sites.

- Results of a Year 5 study indicating that rice hull burning could significantly reduce the soil population of pathogenic fungi were confirmed in Year 6. The incidence and severity of pink root infection in onion was lower and onion yields were higher in plots in which rice hulls were burned, compared to unburned plots. Partial budget analysis showed that rice hull burning can provide a net benefit of P188,958 per hectare (1$ US = P 38).

- Several plant species had strong nematicidal activity against the root knot nematode. Highly active extracts were prepared from neem tree, papaya, Euphorbia and kuyot. Use of *Tagetes* sp. and two *Crotalaria* spp. reduced the number of galls and nematodes in roots and soil.

- Planting non-host crops of *Phoma terrestris* in rotation with onion significantly reduced disease pressure, resulting in low incidence and severity of pink root infection. However, crop rotation was not effective in controlling the root-knot nematode.

- Sex pheromone traps detected *Spodoptera litura* and *S. exigua* even before seeding of onion crops. Peaks in sex pheromone trap catches were followed in a few days by peaks in egg density of *S. litura* as monitored in castor plants. Trap catches could be used as a monitoring tool for efficient timing of interventions in the field, thus resulting in reduced costs and insecticide usage in onion.

- Removal of damaged shoots and fruits of eggplant is a viable alternative to insecticide application for the management of *Leucinodes orbonalis*. If implemented at the same time as harvest, labor costs can be cut down drastically. With the drastic reduction or non-use of insecticides, great savings will be realized, leading to high economic returns to farmers. Partial budgets analysis indicated net added benefits of P128,157 per hectare for weekly removal of damaged fruits compared to tri-weekly application of insecticides.

- Several farmers' and commercial varieties of eggplant evaluated were resistant or tolerant to the cotton leafhopper. The farmer's variety SRO2 has dense trichomes that prevented leafhoppers from feeding and oviposition. IPB GS 1, an improved line, has few trichomes but is resistant to leafhopper and yields high. The use of these varieties significantly cut production costs as no pesticide inputs were added. This was coupled with the abundance of natural enemies, which helped reduce and manage leafhopper and borer populations below damaging levels.

- Rice pest predators including spiders, ants, Dermaptera and carabids provide early season control of rice pests. The age of the crop as well as farm operations affect predator movement across bunds, the closest refugia for these predators. In the young crop *Pardosa* (spider) females with eggs or young move from or across the bund and into the field. This trend is later reversed so that the older crop may serve as a source of spiders to neighboring crops. During farm operations, such as harrowing, predators escape into the bunds. Later other groups of predators arrive

and become more numerous than the walking predators. One of the first is balooning spiders, later followed by, among others, a high number of aquatic hemipteran predators. During fallow collembolans and dipterans provide important alternative prey for the predators, thus allowing many predators to survive in and around the field. After the crop is planted, numbers of alternative prey fall dramatically, producing a perfect timing with many hungry spiders at the time of early pest attack.

- The bacterial antagonist *Bacillus* sp. strain LEP 118 has the potential to control pink root and other soil-borne pathogens in rice-onion systems and is most effective if applied as a protective coating on the root surface. *Trichoderma viride* and *Trichoderma* sp. strain T5 were suppressive to the soilborne pathogens *Rhizoctonia solani* and *Sclerotium rolfsii* in laboratory and greenhouse assays.

- Morphologic and genetic variation was observed between the lowland and upland types of the purple nutsedge, C*yperus rotundus.* The results of this study will serve as a basis in formulating short-term and long term integrated weed management strategies in rice-onion rotation systems.

- Development of transgenic Asian eggplant varieties was determined to be feasible but currently limited by funding constraints. However, availability of varieties resistant to the fruit and shoot borer could result in highly significant reductions in pesticide use.

- Bacterial wilt incidence was lower in the eggplant cultivars Jackpot and Dumaguete Long Purple than in the cultivar Abar. Mulching with straw increased the incidence of bacterial wilt compared to unmulched controls. Soils that has been cultivated and not mulched contained markedly reduced numbers of the bacterium. However, yield of eggplant cultivars was higher in mulched than in unmulched plots.

- The environmental benefits of the IPM CRSP were estimated at more than 6 million pesos for the roughly 4600 inhabitants in the villages where the IPM CRSP is immediately centered, or about $150,000 per cropping season.

- Two IPM CRSP papers presented at the Pest Management Council of the Philippines Conference in May 1999 won Best Paper and Best Poster awards. These were: Best Paper (Weed Science) – Agroecological Approaches to Managing Weeds in Rainfed Rice-Onion Systems, by A. Baltazar, E. Martin, M. Casimero, F. Bariuan, S. Obien and S. K. DeDatta; Best Poster (Plant Pathology) – Root Knot Disease Caused by *Meloidogyne graminicola* and its Management in Rice-Onion Systems, by E. Gergon, V. Judal, C. Ravina, R. Gapasin, and J. Halbrendt.

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. Economic analyses have shown that strategies such as appropriate timing of application of herbicides combined with hand weeding in onions, use of microbial biocontrol agents in onions, and removal of eggplant fruits damaged by the fruit and shoot borer, 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.

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 were provided to PhilRice and cooperating institutions in the Philippines.

Student Training
Several students are currently being supported by the project in graduate programs in a collaborating host country university (UPLB) or U.S. institutions. M. Casimero and E. Gergon are pursuing Ph.D. degrees in weed science and nematology, respectively, at UPLB. J. Recta is pursuing a Ph.D. in statistics at Penn State. L. Cuyno completed a Ph.D. in agricultural economics at Virginia Tech.

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. Workshops during Year 6 include

- "Cultural Management Practices and IPM for Vegetables", July 14-15, 1999, PhilRice.
- "Training for Agricultural Technicians and Farmer-Leaders on Rice-Vegetables with Emphasis on IPM", August 2-6, 1999, PhilRice.
- NOGROCOMA (onion growers cooperative) meeting at PhilRice July 30, 1999, involving IPM CRSP scientists, NOGROCOMA members and barangay captains of Bongabon, Nueva Ecija.
- IPM CRSP scientists also developed a training module for IPM in rice-vegetable systems, farmer-appropriate training materials and facts sheets on pest problems.

Bangladesh

Description of the Collaborative Program
IPM activities in the Bangladesh site were concentrated in three program areas during year 6, which was year 1 for Bangladesh. The first of these areas was a baseline survey and crop monitoring. The second was multidisciplinary on-farm 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 6 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 Bangladesh, and b) preparation of joint host-country/US/international scientist two-page proposals. Planning for Year 7 also involved discussion of the plans jointly with scientists working in the Philippine site during the planning workshop at Purdue 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. 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 6 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 (*Pseudomones solanacearum*) and other pathogens in eggplant, various weeds in cabbage and eggplant, soil borne pathogens such as root knot nematodes (*Meloidogyne* sp.) and *Fusarium* in gourds, and aphids and diamond back moth in cabbage.

Selected Research Accomplishments

Descriptions of research progress and results are provided in the individual institution activity reports, but the following are examples and key results obtained in the Bangladesh site:

- Baseline surveys conducted in Kashimpur and Konobari districts provided information on existing patterns of vegetable production and pest management practices. Very little IPM was found currently being practiced on vegetables.
- Monitoring of crop pests and their natural enemies in rice and vegetables identified the most serious insects, diseases, and weeds in the Gazipur district.
- Of the 23 accessions of eggplant tested for resistance to bacterial wilt, root knot nematode, and fruit and shoot borer, none were found resistant, but a few exhibited tolerance to one or more of the pests and will be tested further.
- A trap with the synthetic pheromone lure, Cuelure proved effective in trapping fruit flies in cucurbit crops.
- Results of on-farm experiments in both okra and cabbage found that, instead of the current practice of three or four weedings, farmers can effectively control weeds through deploying two weedings, one early and one mid-growth stage in the crop and generate the highest net returns.
- The first season's experiments found that incorporation of mustard oil-cake in eggplant fields effectively reduces nematode infestations and increases yield.
- Plots with poultry manure incorporated produced taller, heavier bunching onions and has less disease and nematode infestation.
- Sawdust burning and soil incorporation of poultry refuse were effective in reducing deaths of cucumber seedlings, promoted growth of cucumber plants and produced 1.5 times more yield.

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.

Institution Building

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 Indian student at Penn State, Joseph Kodamanchaly, began his dissertation research in sociology with a focus on factors influencing IPM adoption in Bangladesh. One Bangladeshi student, Chowdhury Mahmoud, began his MS program in agricultural economics at Purdue.

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 though visits to other countries and participation in workshops, meetings, and other networking activities. U.S. universities also help with networking in the region. The Bangladeshi student at Purdue was formerly a research assistant at the office of the International Food Policy Research Institute (IFPRI) in Dhaka, and avenues for future collaborative work with IFPRI scientists are being explored. Some of the scientists on the project also work with the Philippines site, including the weed scientist from UPLB working in the Bangladesh site. One US scientist on the project also works with the SANREM CRSP in SE Asia, providing

another opportunity for networking within the region and the CRSP system.

EASTERN EUROPEAN REGION

Albania

On October 29, 1998, a meeting was held at OIRD with Dr. Phil Warren (USAID/ENI), Dr. Joe Pastic (USAID/Albania), Virginia Tech, and Penn State University participants, to discuss the Participatory Appraisal and workplan for the period in which Albania was closed to US co-Pis (Aug. 1998 - Apr. 1999). A PowerPoint presentation was made on the interaction between olive IPM and Albanian history and politics. The Baseline Survey was executed in Albania in January 1999. This survey is an integrated activity that describes the socioeconomic context of pest management in olive production in Albania. It provides background and context for the experimental studies to be carried out by IPM CRSP/Albania. The main purpose of the Baseline Survey is to identify the farmers' stock of knowledge and their perceptions regarding olive pests, natural enemies, and pest management practices, as well as to specify their knowledge gaps with respect to olive pest control.

Description of the Collaborative Program
Albanian scientists are distributed across disciplines (Entomology, Plant Pathology, Crop Protection, Agricultural Economics, and in three institutions: Agricultural University of Tirana, Plant Protection Research Institute (Durress and Fruit Tree Research Institute (Vlore).

The entire budget for the Albanian CRSP project originates from the USAID Mission in Tirana through the Global Bureau of USAID. This will support all objectives in the plan of work. We will investigate potential collaboration with VOCA.

Albanian and American scientists met in Tirana after the farm visits during the PA to develop proposal, and to sign up individual faculty with projects of interest.

IPM Constraints Researched
Overview of IPM constraints in the country/region. By 1990 the cumulative effects of Albania's central planning system had led to an economic crisis. The transition from a centralized system to a market economy brought about radical changes concerning the nature of basic elements of Albanian agriculture (the production process, farmers, the farm and farm business) as well as the functioning of essential support services. Currently pesticides are seldom available to growers. The result has been uncontrolled populations of some key pests, but establishment of natural enemies for other pests. A challenge is to develop control for the key pests that are nondisruptive to existing beneficial populations.

Examples of research progress. The research in only now getting underway. The Baseline Survey was completed, providing a detailed evaluation of the nature of the Albanian olive industry and pest management problems.

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 U.S. relates to observation of IPM systems in perennial cropping systems under a regime of low pesticide availability. American commodities are facing loss of key pesticide groups, and specialists will benefit from working in the Albanian system.

Selected Research Accomplishments
The most important findings relate to the level of grower education, and the inadequacy of a viable extension system.

- A valuable descriptive cross section of the Albanian olive industry was created. This included size of crop, marketing outlets, main pest problems, etc.

- Significant gaps in grower educated were revealed. Farmers gave diverse responses regarding the nature of damage caused by olive pests. They generally could give a description of the damages caused by pests on olives, but in some cases they failed distinguish between certain pests. In many cases their description of pest damages did not match those of respective pests. Farmers' knowledge about the natural enemies of olive pests was very limited. Even those farmers, who responded, seemed a little bit surprised about this question because they had never thought about it. Farmers revealed little awareness with respect to the potential harmful effects of pesticides on human health and the environment. The majority of farmers either did not agree or expressed no opinion that pesticides can harm water quality.

- There are significant obstacles to farmers obtaining agricultural credit. Only 38% of respondents consider it possible to borrow. The rest stated they have not tried to get credit because there are so many constraints and the interest rates are too high.

- Farmers mentioned various reasons for the credibility of sources of pest advice in olives. Most of respondents indicated that extension specialists are more credible as a source of advice because they are more knowledgeable, have more experience, have university education, tell what and how to do things. However, no farmer interviewed quoted extension specialists as being accessible. A small number of respondents also considered research specialists as a credible source of information for being knowledgeable and experienced, but not accessible in most of the cases. Only two percent of farmers reported to have participated in a training course related to pest control in olives. However, the overwhelming majority (82.5%) said they are willing to participate in such courses in the future.

Networking Activities

On October 29, 1998, a meeting was held at OIRD with Dr. Phil Warren (USAID/ENI), Dr. Joe Pastic (USAID/Albania), Virginia Tech, and Penn State University participants, to discuss the Participatory Appraisal and workplan for the period in which Albania was closed to US co-Pis (Aug. 1998 - Apr. 1999). An e-mail network was set up recently to support such sharing of information.

IPM CRSP - WIDE ACTIVITIES

Gender Equity Programming in the IPM CRSP for Sectoral Growth

The IPM CRSP was designed, and has been implemented, with a strong gender-equity component. The CRSP is committed to the equitable involvement of women as both program scientists and beneficiaries. The Management Entity of the IPM CRSP, Virginia Tech's Office of International Research and Development (OIRD), designed and is implementing a program that ensures that these program benefits will be equitably distributed among women and men. As a research program, the focus of gender-equity programming has been on research into the likely outcomes of IPM research activities for women and men, and on involving women farmers in these activities, in order to ensure that women's livelihood strategies receive equal attention with those of men. With a view to sectoral growth as well as to equity issues, programming is designed to ensure that women who produce targeted crops are included in research and dissemination activities.

The IPM CRSP has investigated linkages among measures of gendered resource ownership and control, women's access to and use of IPM and other agricultural technologies, productivity, agricultural incomes, and women's control of income in Africa, Asia, Latin America, and the Caribbean. Research methodologies include participation by women stakeholders at all levels in participatory appraisals used to guide program planning; probability sampling of households in areas where the CRSP is engaged in research, with participation by both women and men; and ethnographic studies of women's roles in household production, resource ownership and control, income, and access to development programs. Findings have been disseminated to interdisciplinary research teams of U.S. and host-country scientists. Recommendations for the inclusion of women farmers in technology development, as well as in related extension efforts, have been made for several sites, including those in Uganda, Mali, the Philippines, Guatemala, and Jamaica. Intrahousehold research is under way in Ecuador.

In Mali and Uganda, these recommendations have resulted in attention to women's crops and production constraints, and to technologies that improve women's food processing enterprises. Half of producer groups involved in IPM research in Uganda are female-oriented. Research findings from Uganda demonstrated that women are more likely to use pesticides than men, owing partly to their crop choices and corresponding market niches. These findings contribute to recently emerging studies in all regions showing that women are more likely to be high-technology commercial producers than influential earlier WID studies had shown. In Jamaica, where there is much less gendered division in crops and tasks, women farm and/or market all CRSP crops. Community-level outreach is attempting to ensure that women farmers are made aware of field days and other activities associated with CRSP research.

In Guatemala, women specialize to some degree in non-CRSP commercial crops, but work in CRSP-focused household production, as well, in 94% of households surveyed by the CRSP. According to their husbands, women make relevant land use decisions in three-fourths of these households, and pest management decisions in one-third of households. The CRSP is now focusing on targeting research to women, to determine their perceptions of their roles in pest management and their evaluation of access to and control of resources and their primary production constraints. Women attend field days and other extension activities, but have participated less than their husbands. Extension-related host-country

colleagues are considering mechanisms to provide women with female-oriented activities. These activities will focus on agricultural productivity rather than traditional "women's activities," but will be presented in a female-oriented environment.

In the Philippines, household surveys and ethnographic research have demonstrated that even women who do not work in the fields often control funds used to purchase IPM technologies, and thus should be included in all information campaigns. Filipinas are somewhat more likely than their husbands to prioritize spending for pesticides, as they are less inclined to risk crop loss, but are also more likely to be receptive to cost-effective IPM practices. The CRSP involves Filipina farmers in several contexts. One of these is a large export-oriented production cooperative headed by a woman and whose financial resources are controlled and channeled primarily through women officers and employees despite the fact that the membership is primarily male. Wives of male members are encouraged to attend meetings, either together with husbands or in their stead, and they do so. Earnings from household agricultural production are pooled and managed by wives. Gender-egalitarian control of household financial resources is not unique to this cooperative, but has been reinforced by gender-egalitarian control of cooperative resources.

The Management Entity is fully committed to gender equity issues among both scientists and project beneficiaries. Under the leadership of the Management Entity, the IPM CRSP has worked to ensure that both US and host-country women scientists are involved as investigators. Although these efforts have been somewhat more successful within host countries, the number and disciplinary diversity of scientists from the U.S. is increasing. The gendered division of graduate training awards has been equitable.

Two of eight US Site Chairs are women. Three of 11 host-country Site Coordinators are women. The Management Entity encourages the participation of the OIRD gender specialist as an investigator; she has been involved in research in most of the regions of the CRSP

It is important that gender issues receive increased attention from the Technical Committee, as the progress of gender equity issues on the IPM CRSP has depended largely upon the good will of collaborating institutions and the quality and impact upon them of gender-related social-science field research. In spite of direction from both USAID and the Management Entity, several institutions continually fail to meet their resource commitments for gender-related research. In some of these institutions, dedicated researchers have contributed to progress on gender equity issues despite the failure of these institutions to honor commitments they have made to allow their scientists time to participate in gender-related research.

In summary, the IPM CRSP features an approach that is genuinely committed to gender equity issues. This commitment can be seen most clearly in the record of graduate training, host-country scientist participation, global gender-focused research, and increasing incorporation of women farmers in collaborative research and extension efforts. These positive results would be multiplied if all partner institutions were held strictly accountable for meeting their commitments to gender-focused research, and, where relevant, to related extension efforts.

Board of Directors

The Board of Directors of the IPM CRSP annual meeting was held at Virginia Tech on 30 - 31 March 1999. Attendees were:

Appointed members: Ed Kanemasu (Board Chair; University of Georgia), Ikbal Chowdhury (Lincoln University), David Sammons (Purdue University), Santiago Obien (PhilRice), S.K. De Datta (Virginia Tech), Tom Mew (IRRI), David Denlinger (for Bobby Moser; Ohio State University), Ed Rajotte (for Paul Backman; Penn State University), (Rick Bennett, USDA unable to attend)

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)

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

Minutes of the Board Meeting are available on request. Major decisions made by the Board included:

- The Board should express in a letter to Emmy Simmons, John Lewis, Sally Shelton, and USAID Administrator concern for the apparent lack of congruence between review results and allocation of resources.
- The Board recommended that the TC and EEP use the "Criteria for resource allocation across country sites in Phase II" write-up by George Norton when determining resource allocation this year.
- The ME and the host country representative on the Board (currently Santiago Obien) will make set of criteria for choosing the Site Coordinator.
- The Board recommend that the Executive Committee (EC) of the Technical Committee (TC) consider inclusion of an external member. Also, the EC could rotate out one member per year to have continuity.
- The IPM CRSP, in order to fulfill its duty to consider cutting edge research, should consider transgenic plants at its various sites, to the limits of its resources with special consideration of projects with potential high impact.
- Collaborating scientists can be brought into the IPM CRSP to fill a particular niche, modality of arrangement can be decided on a case by case basis, and that scientist's activity with the IPM CRSP will terminate with that project.
- The Board agreed to send a plaque to Tom Payne to express the Board's appreciation for serving well for 5 years as Chair of the IPM CRSP Board.
- The Board concurred with the following changes: in Year 6 the EEP had a new member, Laurian Unnevehr (U. of Illinois), who replaced Mel Blasé, on the Board of Directors, Bob Moser replaced Tom Payne, Rick Bennett replaced Jennifer Sharp, and Tom Mew replaced Paul Teng. On the Technical Committee, N.S. Talekar replaced K.L. Heong.

Technical Committee

The IPM CRSP Technical Committee (TC) held several conference calls during the year and held its main annual meeting at Purdue University in West Lafayette, Indiana, on May 6-9, 1999. Technical Committee (TC) members who attended the Purdue meeting were:

Sally Miller, Site Chair, Asian Site in the Philippines
George Norton, TC Chair, and Site Chair, Asian Site in Bangladesh
Sam Kyamanywa, Site Coordinator Representative
Mark Erbaugh, Site Chair, African Site in Uganda
Brhane Gebrekidan, IPM CRSP Program Director
Greg Luther, IPM CRSP Assistant Program Director
N.S. Talekar, International Agricultural Research Center Representative
Charlie Pitts, Site Chair, European/Eurasian Site in Albania
Roger Williams, Site Chair, South American Site in Ecuador
Glenn Sullivan, Site Chair, Central American Site in Guatemala
S.K. De Datta, Principal Investigator, IPM CRSP
John Caldwell, Site Chair, African Site in Mali
Sue Tolin, Site Chair, Caribbean Site in Jamaica
Bob Hedlund, IPM CRSP Project Manager, USAID
Seymour van Gundy, Temporary External TC Member (Michael Irwin unable to attend).

The minutes for this meeting are available on request. In addition to the Technical Committee

members, many other IPM CRSP scientists gathered at Purdue to plan for the upcoming project year (IPM CRSP Year 7).

Major decisions made and motions passed during the meeting included:

- A transgenics issues committee was formed to prepare a document as a guide for the Site Chairs and other IPM CRSP scientists on this topic. Sue Tolin, N.S. Talekar and George Norton will make up this committee.
- A global training plan to further IPM institutionalization is being drawn up. This training document will cover the next 4 years.
- The list of the IPM CRSP Publications, Presentations, and Other Products of the IPM CRSP (available on request), and a summary of the totals for a variety of categories (Table 1).
- The IPM CRSP will decide what the probable funding base will be for the next 3 years, and then have a portion of the budget that is flexible for rewarding sites.
- It was agreed that the IPM CRSP must produce more scientific publications out of each site.
- The Executive Committee (EC) of the TC met before the TC Meeting and came up with a recommended budget to be a starting point for discussion amongst the entire TC as follows:

Starting Point Budget from Executive Committee	
Guatemala	$ 180,000
Ecuador	$ 155,000
Jamaica	$ 120,000
Philippines	$ 190,000
Bangladesh	$ 180,000
Mali	$ 130,000
Uganda	$ 195,000
Global Themes	$ 50,000

After much discussion, the TC adopted the EC-recommended budget as the budget for Year 7.

Table 1. Publications, Presentations and Other Products of the IPM CRSP
Cumulative Compilation through May 1, 1999

Category	General / Other	Albania	Bangladesh	Ecuador	Guatemala	Jamaica	Mali	Philippines	Uganda	Total
Papers Published in Refereed or Reviewed Publication	0	0	0	0	3	14	2	4	3	26
Proceedings	14	0	0	0	64	10	9	42	7	146
Theses And Dissertations	0	0	0	1	3	0	2	2	0	8
Papers/Seminars Presented	0	1	0	0	55	18	11	4	8	97
Abstracts	0	0	0	0	2	7	1	2	2	14
Electronic Presentations	0	0	0	0	0	4	0	0	1	5
Fact Sheets	0	0	0	0	0	1	0	0	3	4
Workshops	0	0	0	0	0	3	0	0	0	3
Newsletters	10	0	0	0	0	1	1	0	1	13
Extension Publications	0	0	0	0	4	6	1	0	0	11
Reports	27	4	4	11	123	105	63	91	40	468
IPM CRSP Annual Reports	5	0	0	0	0	0	0	0	0	5
IPM CRSP Working Papers	2	0	0	0	3	0	3	6	1	15
Germplasm Releases	0	0	0	0	0	4	0	0	0	4
Videotapes	0	0	0	0	0	1	1	1	0	3
World Wide Web Sites and Documents	2	0	0	0	0	3	0	0	0	5
Books/Book Chapters	0	0	0	0	2	0	0	0	0	2
Bibliographic Databases and Miscellaneous	0	0	0	0	0	0	0	6	0	6
Posters	1	0	0	0	3	11	0	1	0	16
Magazine and Newspaper Articles	0	0	0	0	1	0	0	0	0	1
Total	61	5	4	12	263	188	94	159	66	852

External Evaluation Panel (EEP) Reviews

The External Evaluation Panel (EEP) of the IPM CRSP conducted a review in Year 6 at Purdue University in West Lafayette, Indiana, on May 4-5, 1999. Members of the present EEP are Don Plucknett (Chair), Sonny Ramaswamy, Doug Rouse and Laurian Unnevehr. In addition to the meeting at Purdue, Ramaswamy visited and reviewed the Uganda site on December 12-22, 1998.

The complete report of the full EEP review at Purdue is available on request. However, the main points of this review are shown below:

Summary of the EEP report to the CRSP leadership.

- The Panel was worried about (i) **Too little money for the task**, and (ii) **Too many sites for the money**.
- An overriding concept that underpins the CRSP is that Participatory IPM is the major task of the CRSP, and that the CRSP has a major responsibility (i) to carry out Participatory Appraisals (including baseline surveys and monitoring studies) and (ii) that the PA process needs to be analyzed for lessons learned and publications prepared. In doing this, it must be remembered that getting IPM going in developing countries is the task of the CRSP, and the process involved in making it successful is important.

The Panel reviewed criteria prepared within the CRSP to assess the 'mature' (or 'maturing') sites – Jamaica, Guatemala, Mali and Philippines, plus Uganda which has had 5 years of operations. Criteria were: i) productivity, ii) impact (potential or demonstrated), and iii) overall management effectiveness. Using the criteria, the Guatemala, Philippines and Uganda sites rated high, while Jamaica and Mali did not.

Sonny Ramaswamy's full report on his Uganda review is available on request. However, his summary and recommendations sections are copied below.

1) Overall Observations

I was pleasantly surprised by how welcoming Uganda was and with the potential for excellent economic progress, especially in the agricultural sector. Uganda is a country poised to make dramatic gains in improving its lot, and the activities of IPM CRSP are very much in congruence with those of the National Agricultural Research Organization (NARO). Every one of the players involved in IPM CRSP appears to be *in synch*, supporting each other's research activities to the extent that significant returns are expected. A major contributor to such a state of affairs is the phenomenally congenial atmosphere amongst the various players and, especially, the very close working relationship of the Site Chair, Mark Erbaugh, and Site Coordinator, Sam Kyamanywa - the chemistry is perfect! Mark's and Sam's close working relationship has energized this site and is key to the close coordination of activities and the morale of the American and Ugandan scientists. Additionally, soliciting input from all site participants into experimental design, workplans, research accomplishments, etc., during an annual meeting is to be commended. The Ugandan IPM CRSP collaborators have a well-coordinated organizational structure with the leadership of Makerere University (MU) personnel. I was impressed with the dedication of the team members in this effort, but they have a daunting task in improving the lot of the average Ugandan farmer who farms small plots. The experiments planned or under way may be in jeopardy with the extended drought. The scientists are encouraged to develop contingency plans for greenhouse/laboratory experiments.

Every one of the administrators I met with at MU and NARO were of the opinion that IPM CRSP has been a tremendous synergist for the coordinated agricultural research activities pertaining to pest control within Uganda. The major refrain was that they are excited about the activities of IPM CRSP and wondered why they could not be extended to other commodities such as livestock and horticultural products. I heard similar responses from farmers in the Kumi and Iganga districts, suggesting that both stakeholders and clientele are appreciative and supportive of IPM CRSP activities. The Ugandan IPM CRSP team needs to be careful, lest it gets further over-extended by taking on additional commodities, exacerbating an already stretched-too-thin situation. My recommendation is that they not

undertake work with additional commodities at this time, unless they receive a significant increase in their operating funds.

Component research in several areas are being undertaken and integration of some of these various facets is also being undertaken. Transfer of technology is the next step. The IPM fact sheets, pest identification aids, workshops, etc. being developed will help in this effort. The Ugandans need to undertake these latter aspects at an accelerated pace. Additionally, I saw very little effort at determining the impacts of the IPM CRSP activities i.e., the participatory appraisal activities need to be followed continually. Especially since this site, like the others, is at the end of Phase I and the beginning of Phase 2, this is an opportune time to determine the impacts of the several years of IPM CRSP activities to allow the necessary adjustments for Phase 2. The Ugandans have capitalized only in part on expertise available at ICIPE and CIMMYT, and there is little evidence of inter-Site linkages, even within Africa. Such linkages need to be encouraged so that expertise available from within the IPM CRSP family may be used. The ME is encouraged to provide any help in these efforts.

My assessment of the situation in Uganda is that this site is at the verge of making a major contribution to the IPM effort in Africa. This assessment and optimism is shared by every one of the individuals I had the opportunity to visit with.

2) Recommendations

- All of the IPM CRSP scientists need to rapidly complete data analysis and publication of their research results. In this vein, several of the scientists complained they do not have access to computers for data analysis. IPM CRSP must make the effort to help alleviate this situation.
- Socio-economic analyses and cost-benefit analyses need to be undertaken to allow determination of the efficacy of IPM CRSP activities.
- Training opportunities at MU be considered for Malian and Eritrean students.
- Short term visits by Ugandan scientists and graduate students to US institutions for workshops and specialized training be encouraged.
- The IPM CRSP scientists associated with MU do not have a reliable vehicle to travel to work sites. They have ingeniously refurbished an old vehicle that is used for travel over long distances, but the safety and well being of the driver and riders are not guaranteed. I recommend that this site be allowed to purchase a used vehicle of more recent vintage.
- Graduate students being trained at MU are paid a stipend of $120 by IPM CRSP, compared with their cohorts who are paid $200 for work on similar projects being funded by other international agencies. Probably the most significant and lasting impact of IPM CRSP is developing the infrastructure and making available trained personnel. I recommend that IPM CRSP make the effort to equalize stipends being paid to their students with those of other students.
- African IPM CRSP scientists (from all three sites) have annual IPM workshops and symposia in conjunction with their efforts to develop annual workplans.
- The ME make every effort to increase the line of credit to $25,000 and hasten the reimbursement of bills submitted by the Site Coordinator.

Addition of 1890 Institutions

In Year 6 of the IPM CRSP, a fifth 1890 Institution was added to the program: Florida A&M University. Four other 1890 Institutions remain members of the IPM CRSP consortium. These are:

Lincoln University
University of Maryland, Eastern Shore
North Carolina A & T University
Fort Valley State University

Trip Reports for Year 6

Trip reports from Year 6 of the IPM CRSP totaled as follows:
Albania: 1, Bangladesh: 3, Ecuador: 1, Guatemala: 2, Jamaica: 4, Mali: 6, Philippines: 2, Uganda: 4. These reports are all posted on the IPM CRSP web site,
http://www.cals.vt.edu/ipmcrsp/index.html

Technical Assistance

A. Environmental Quality Laboratory in Mali

In Year 6, the Mali Site of the IPM CRSP began collaboration with the Environmental Quality

Laboratory (EQL) of Mali, to address needs in pesticide residue analysis, environmental monitoring, and development of a quality assurance program for agricultural products in Mali. The EQL, a part of the Central Veterinary Laboratory, has a comprehensive mandate that reflects the needs of Mali and the West African region for the analysis of pesticide residues on crops, food, and medicinal products, and in water, soil, and sediments. Data it will obtain on pesticide residues will assure the safety of agricultural products for home and market consumption in Mali and West Africa and for export to global markets that include the United States as well as Europe. These data will also serve as the base for the standardization of pesticides used throughout West Africa, the development of strategies for the selective use of appropriate pesticides in the subregion, and the development of educational programs to help vendors and farmers use pesticides in a safe and more environmentally sound basis.

The IPM CRSP worked with the EQL during the first half of 1999 to develop a program of collaboration and a corresponding proposal. Funding at a level of $530,000 for the five-year program was subsequently approved by the USAID/Mali Mission.

The new program began on July 17, 1999 with a four-week training and collaborative visit at Virginia Tech by EQL Director Dr. Halimatou Koné Traoré and EQL laboratory specialist Dr. Safiatou Berthé. During these four weeks, in collaboration with IPM CRSP scientist Jean Cobb and the staff of the Pesticide Residue Laboratory (Department of Biochemistry), Dr. Traoré and Dr. Berthé focused on techniques for residue analysis of deltamethrin, the principal pesticide used on green beans, the most important Malian export horticultural crop. Additional training in instrumentation was provided by staff of the Chromatography Laboratory (Department of Chemistry). Parallel to the laboratory work, Dr. Traoré and Dr. Berthé also interacted with Don Mullins and Pat Hipkins (Department of Entomology) and John Caldwell (Department of Horticulture) to learn about pesticide safety, quality assurance, and extension programs relevant to Malian needs.

B. Gall Midge Project in Jamaica

In Year 6 a proposal was written for Jamaica entitled, **"**National Strategic Plan To Combat The Gall Midge Complex Affecting Hot Pepper." It was subsequently approved for funding, with the USAID/Jamaica Mission supplying $45,000 and the IPM CRSP $45,000 for a two-year project.

The project commenced at the beginning of IPM CRSP Year 7 (September 29, 1999). The goal of this activity is to address fundamental issues surrounding the emergence of new pests, the gall midges *Contarina lycopersci* and *Prodiplosis longifilia*, and their impact on the hot pepper export market. There are six major components to this project: (1) Determine the biology and taxonomy, behaviour and ecology of the gall midge complex. (2) Develop an Integrated Pest Management strategy. (3) Improve post-harvest technology and its application for export fruits. (4) Transfer IPM technologies to farmers and extension officers. (5) Make the public aware of the importance of the gall midge complex. (6) Monitor and analyze the introduced IPM technologies.

Expected outputs of this project are: (1) Improvements in the quality and quantity of exportable and local hot peppers. (2) Development of IPM options for managing gall midge populations. (3) Improvements in the knowledge base of farmers in pest management. (4) Increased number of farmers/extension trained in IPM. (5) Knowledge of the relation of the gall midge with respect to phenology of the crop and agroecology.

Projected impacts are: (1) Reduced fumigation of exported produce, reducing the environ- mental hazard. (2) Increased hot pepper production, resulting in increased income to producers. (3) A tracibility system for hot peppers grown for export. (4) Improved coordination and information flow among persons within the hot pepper industry.

SELECTED IMPACTS FROM THE REGIONS

Africa-Wide

- In electronic based communications, closer collaboration among and between African and American scientists has improved.
- Increased networking opportunities for African scientists has been achieved.
- African IPM information hubs of AIL and IPM CRSP contact points will encourage researchers, NGOs, and the private sector to make their own information available to a greater number of African stakeholders.
- Maintenance and improvement of both the IPM CRSP and the AIL web sites continues to enhance information availability for researchers, extension agents, and NGOs which in turn is expected to enhance IPM knowledge transfer to farmers.
- Improved understanding by our African partners of the power of Email and the WWW for IPM information sharing and establishing contacts continues to improve their IPM knowledge base.

Mali

- In one of our trial sites in Mali, the use of yellow traps alone on thrips was the most profitable technology with net additional benefits of $4,443 per hectare compared to $4,233 per hectare for yellow traps plus neem. At a second location near Bamako, however, the use of yellow traps and neem oil had a higher net additional benefit than the use of yellow traps alone

- The combination of sticky traps and neem in green beans production is comparable to the farmers' standard practice, two applications of Decis, in levels of insect control, amount of pod damage, and yields.

- In the first 4 years of this project, we identified a local (harvestable within each village) natural product with pest management potential in preharvest and postharvest IPM systems in the Sahel and near-Sahelian areas of Mali. We have tested by-products of the plant *Azadirachta indica* and developed several formulations appropriate for use in villages in Mali

- A gender difference with implications for insect and disease IPM was found in a preliminary survey, with men responsible for the application of insecticide, while watering primarily done by women and children..

- Continued experiments on a potentially useful new strategy for the integrated control of *Striga* in sorghum and millet. The herbicide prosulfuron appears to have the characteristics to be effective in the control of *Striga* and initial results are encouraging.

- The development of national capability in the Environmental Quality Laboratory (EQL) to analyze pesticide residues will assure the safety of agricultural products for home and market consumption in Mali and West Africa and for export to global markets that include the United States as well as Europe. Our EQL collaborative work will serve as the base for the standardization of pesticides used throughout West Africa, the development of strategies for the selective use of appropriate pesticides in the subregion, and the development of educational programs to help vendors and farmers use pesticides in a safe and more environmentally sound basis. The program will also develop a pesticide monitoring system for sampling and analysis of pesticides on agricultural products. This will begin with priority crops for export (green beans, hibiscus flowers, and mango) and local

markets (tomato and lettuce). Through this new collaborative program in partnership with USAID and the IPM CRSP core research program, the EQL will not only acquire the technical skills needed to address pesticide residue analysis needs in Mali, but it will also develop the capability to serve as the premier laboratory of its type in West Africa

Uganda

- A survey of maize diseases in Uganda demonstrated the importance of gray leaf spot (GLS). Our gray leaf spot research efforts have potential for impact both in Uganda and the United States. Perhaps the best example from the Uganda site is the work being done on identifying genetic resistance to gray leaf spot, the number one foliar disease of maize in Uganda and in the US corn belt. We identified GLS resistant germplasm with acceptable agronomic performance in both Ohio and Uganda.

- Bean grain yields on seed dressed and earthed-up plots were demonstrably higher compared to the untreated bean plots, resulting in adoption of seed dressing technology by farmers in groups we have been working with. To ensure that the technology is disseminated on a larger scale, this technology has been passed to the IDEA Project (IDEA is a USAID funded project). IDEA is now conducting nation wide demonstration trials for bean growers. IPM CRSP and IDEA have produced a fact sheet and posters for use by extension workers. It is hoped that adoption of this technology will boost bean production in the region, leading to reduction in malnutrition and poverty.

- The study has that shown *C. partellus* is the most important stem borer of maize and that its parasitoid *Cotesia flavipes* has established itself in Iganga and Kumi. Therefore, the parasitoid is likely to reduce the damage by *C. partellus* and increase maize yield.

- An integrated management option consisting of a of tolerant sorghum variety, Seredo, modest fertilizer application, two hand weedings and interplanting with *Celosia argentia* can minimize the impact of *Striga* parasitism on sorghum. Economic analysis indicates the use of fertilizer is economic only on the improved sorghum variety. We have confirmed that *C. argentia* indeed influences *Striga* emergence and subsequent sorghum grain yield. In 1999, IPM CRSP Uganda worked with farmers and confirmed that *C. argentia* can suppress *Striga* in farmers' fields and the farmers of Kumi district have expressed interest to use it.

- The aggregate economic impact of IPM technologies has been assessed using partial budget analysis and economic surplus methods for Uganda. The Maize variety Longe-1 and seed dressing for beans are being evaluated. From preliminary results of the partial budget analysis, all treatments give higher net return than the farmers' practices.

Guatemala

- If open market supply channels implement the same production and post-harvest handling practices as the grower-shipper and contract producer supply channels, practices that are consistent with U.S. Good Agricultural Practice guidelines, the volume of snow peas culled would be reduced and the cost per unit of snow peas exported would decrease. It is also likely that the adoption of these practices would play an important role in maintaining and increasing access to North American markets by preventing future FDA detentions and events such as the snow pea-leaf miner crisis. In turn, this change would increase net operating profit for exporters and increase economic sustainability at all levels. Therefore, this research concludes that snow pea producers and exporters would benefit from an industry-wide implementation of uniform production and post-harvest handling

practices which are consistent with U.S. Good Agricultural Practice guidelines.

- The establishment of an effective quality control program for snow peas that will guarantee 1) the quality of the product to the final consumer, and 2) the sustainability of the snow pea industry in Guatemala are main impacts of the IPM CRSP research. In addition, it is expected that in the next 2-3 years the majority of Guatemalan snow pea exporters will implement the IPM CRSP-generated ICM production guidelines.

- Papaya ringspot potyvirus (PRSV) has not been officially detected in Guatemala, as it does not appear in the listings of the International Regional Organization of Plant Health (OIRSA). As is the case in many developing countries, the presence of important plant diseases has not been detected. Growers, even though they may be familiar with the symptoms, do not know how to deal with such diseases and incur severe losses. The detection and quantification of important plant diseases such as PRSV represents the first step in the development and implementation of appropriate IPM programs for many non-traditional agricultural export crops, including papayas.

- Although still in the initial stage in the development of a massive rearing procedure of the parasitoid *Diglyphus*, a fundamental aspect of this process was achieved, as snow peas, common beans and green beans were determined to be suitable hosts for leaf miner larvae colonization. These larvae are to be utilized as hosts for the parasitoid, during the breeding process being developed at ICTA's experimental station in Chimaltenango. The long-term impact of this study will be to release vast numbers of *Diglyphus*, as a biological control for the snow pea leaf miner, *Liriomyza huidobrensis*.

- The integrated technology of three or more management tactics (seedlings in transplant plugs, sorghum barriers, yellow plastic traps, and rational use of chemicals) were effectively validated as white fly management tools in tomatoes grown in Guatemala in the control of the white fly viral complex. Revenues were increased, mostly derived from increased yields and reduced variable costs associated with insecticide applications.

- The use of plastic screens of a 50-mesh size, incorporated into the previously developed integrated management for white flies in tomato, had the following effects: a) substantially reduced adult white fly populations; b) significantly reduced the incidence of viral diseases; c) reduced the variable costs compared to the farmer' technology; d) increased the yield and profitability; and e) reduced the number of insecticides' applications.

- The IPM CRSP work has demonstrated that there is a higher response to the optic stimulus that yellow traps produce on the populations of leaf miner (*Liriomyza huidobrensis*), compared with the attractive stimulus of the pulp of fruits. The populations of adults were not different in the treatment with insecticides, compared with the use of traps, which confirms that non-chemical alternatives can be incorporated in the integrated pest management of snow pea. The use of yellow plastic traps with a sticky agent should be used in the crops where the leaf miner is considered as an economically important pest, since it is an affordable practice that reduces insecticide use and does not present risks of contamination to the environment.

- Strip cropping becomes an attractive option for farmers in the highlands of Guatemala. The diversification of crops will favor the long-term sustainability of these export crops and locally marketed vegetables, as well. In addition, the higher diversity will promote the build up of the natural control and help maintain pests at manageable levels. The existence of a healthy agroecosystem will also

prevent the emergence of new primary pests, and better natural control of existing pests. Our results suggest that the Integrated Crop Management (ICM) strategy devised by the IPM CRSP in Guatemala is applicable to multi-crop systems, such as strip-cropping. The ICM strategy increases the economic benefits to the farmer, as profit margins are increased due to reduced usage of chemical pesticides.

- The past year's IPM CRSP research results suggest that new cultivars such as SP 18 or SP 517 may effectively replace Oregon Sugar Pod II as the primary seed material for snow peas grown in Guatemala. However, the experimental line SP 6 could also meet productivity criteria if plant density and yields can be increased. An added attractiveness of SP 6 is the lower numbers of leaf miner larvae it supports, in contrast to the other tested cultivars. Results indicate that SP 6 may be an acceptable cultivar for snow pea production in areas heavily infested with *L. huidobrensis* or, during the dry season when high leaf miner populations are common in the Guatemalan Highlands. Cultivar options other than Oregon Sugar Pod II (in terms of productivity and attractiveness to leaf miner infestation) will prove valuable to farmers and the snow pea industry as a more diverse genetic background in the field should decrease the risks for future pest outbreaks.

- In Guatemala, in ancient times, there was a different knowledge base and specific techniques used for management of pests in crops. Interviews with farmers suggest this knowledge and these practices may allow small producers to maintain sustainable agricultural production for rural families. IPM CRSP surveys indicated that farmers using these practices rely on their own farm-based resources, while maintaining the rich soil. These surveys will insure that much of this knowledge will be rescued, documented, and validated in future research as to its potential for use and incorporation into Integrated Pest Management programs for NTAE crops.

Ecuador

- The addition of sugarcane bagasse and bagasse + ash appears to reduce soil nematode populations. Because some lepidopteran pests are attracted to fresh bagasse it may be possible to apply microbial control agents to the bagasse and thereby achieve some measure of control.

- If *Fusarium oxysporum* in babaco is detected early, a single application of propiconazol alternated with carbendazim could eradicate the disease. It is suggested that the fungicide be applied to apparently healthy plants in the vicinity of diseased plants. Where the disease is established, a combination of eradication of infected plants and fungicide application is recommended.

- Research on soil-borne diseases in potato has been neglected in Ecuador. Most of the farmers do not use cropping plans, crop rotation is reduced and the frequency of potato, an important cash crop, is often high. Elucidating the nature of these diseases, and their role in potato production will help formulate a management strategy for increasing productivity through higher production and improved tuber quality. At this time, only one mating type of the late blight pathogen *P. infestans* is known to occur in Ecuador. IPM CRSP research is designed to demonstrate if any changes have occurred in this situation.

- In Chimborazo the IPC 2 clone 95-9-1 with horizontal resistance was selected by local growers as the most promising selection. The IPC 3 clone P-84-1 was selected as the clone with vertical resistance that had the highest probability of acceptance by local growers. In Carchi clones 95-68-3 and 95-8-2 were selected as the best clones with horizontal

resistance and CHP-3 was the best clone selected by growers with vertical resistance.

- The damage level in the check only reached 12.7%. The nucleopolyhedrosis virus provided a greater effect; only 1.37% of tubers were damaged. The infestation procedure of the stored tubers, by means of adults of *Tecia* will have to be reviewed in order to obtain a better development of the insect population. The use of biological control for *Tecia* will allow potato farmers in Ecuador to avoid intoxication problems and to obtain economical insect control during storage of seed pieces.

- A model is being developed for the geographic region where the potato IPM work is underway on the IPM CRSP. It is proposed that reductions in pesticide use be measured or projected due to generation and adoption of IPM technologies on potatoes and that these pesticide use changes be fed into the bio-economic model as a scenario, with modifications made to the model as needed. It is further proposed that the per unit cost reductions measured or projected due to IPM CRSP technologies be combined with measured or projected information on adoption and included in an economic surplus model to generate aggregate benefits. All changes in input use, outputs, and prices are being measured for each of the CRSP experiments. This information will be used to help generate per unit cost changes.

Jamaica

- Callaloo production is currently heavily reliant on pesticides because its marketability 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.

- Callaloo farmers spray their crop once weekly mainly as a prophylactic treatment against lepidopterous pests. This practice is probably the major contributor to the eroded efficacy of most contemporary pesticides. The introduction of any new chemistry without the implementation of a resistance management program would only again result in insecticide resistance and the cycle would continue. The sampling plan used by the IPM CRSP shows the potential to indicate economic pest population levels and thereby guide farmers in timing spray applications. The development and implementation of this sampling plan was a fundamental step to minimizing pesticide use in callaloo production systems and guiding the sustainable use of new biorational chemistries now available to control lepidoptera species on leafy vegetables. 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 our trials trials, viz. spinosad and tebufenozide are registered for use on leafy vegetables and are therefore ready candidates for use with the developed sampling plan.

- Previous IPM CRSP-funded research conducted at the U.S. Vegetable Laboratory has shown that none of the *Capsicum chinense* cultivars currently available to U.S. and Jamaican farmers are resistant to the southern root-knot nematode. This nematode is a severe pest of this pepper species and the utilization

of resistant cultivars would be the ideal way of addressing the problem. The previous research resulted in the discovery and release of three southern root-knot nematode resistant Scotch Bonnet-type germplasm lines. The results available so far indicate that the utilization of classical plant breeding methods can be used to quickly incorporate southern root-knot nematode resistance into *C. chinense* cultivars. The Habanero has become a popular pepper in the U.S., and the availability of a root-knot nematode resistant Habanero cultivar would provide U.S. growers an alternative to the use of soil fumigates to control root-knot nematodes in Habanero plantings. West Indies Red is a leading processing cultivar in Jamaica, and a root-knot nematode resistant version of this cultivar should be a valuable tool for use in any IPM program designed to control pepper pests in Jamaica.

- The peanut root-knot nematode is a potentially a major pest of pepper. Parasitism of susceptible cultivars results in severely stunted plants and significantly reduced yields. The ideal method to control this nematode in *C. chinense* plantings would be to use resistant cultivars. The results of this study indicate that a single dominant gene conditions the high level of resistance to the peanut root-knot nematode exhibited by the *C. chinense* germplasm line PA-426. This finding confirms the results of the inheritance study conducted in 1998.

- Hot peppers (*C. chinense*) are very popular in the Caribbean market and have become increasingly important as an export crop to the U.S.A. and other countries. Root-knot nematodes (*Meloidogyne* spp.) cause severe yield losses in pepper worldwide. The loss of many nematicides from the market and increased public awareness of the environment has focused interest on the use of host resistance, if available, for managing root-knot nematodes in vegetable crops. Thus, the root-knot resistant Scotch Bonnet-type pepper lines PA-353, PA-398, and PA-426 should be a useful component of an integrated pest management system for hot pepper.

- 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.

- 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 a IPM strategy to reduce infestations was the focus of the activities and included both pre and post harvest investigations. During the past 12months, 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. The ultimate release of a cream or dry fleshed sweetpotato cultivar with resistances to root-knot nematodes, Fusarium wilt, and insects will address some of the major constraints facing the sweetpotato industries in the USA and Jamaica.

- Findings offer CRSP researchers and cooperating extension specialists an opportunity to better serve needs of all farmers who produce target crops and make relevant pest management decisions, regardless of gender. Increased adoption of IPM should result, enabling related improvements in farm income, health, and resource-base sustainability. Women appear to be differentially constrained with respect to IPM adoption, as they may have less access to CRSP project activities and related extension

than men may. This is particularly problematic, as women produce targeted crops and make pest management decisions, but may have less knowledge of pests than men. Women are unlikely to face differential labor constraints owing to potential IPM adoption.

Philippines

- Our data confirm results obtained in year 5 in the Philppines, showing that one herbicide application followed by one hand weeding can provide sufficient weed control with no significant reduction in yields. The total cost of weed control can be reduced by 50-60%, which means a lower cost of production and thus increased profits for farmers. As a benefit to the U.S. this study provides comparison of chemical and cultural methods of weed control in the tropics vs. purely chemical methods in the U.S.

- The occurrence of *C. rotundus* in both onion and rice crops poses more problems to farmers. Results of our study show morphologic and genetic variations between the upland and lowland ecotypes of *C. rotundus*. Our observations in this study will be used as a basis in the development of management strategies to control *C. rotundus* in rainfed rice-onion systems. The lowland and upland types of *C. rotundus* may respond differently to herbicide treatments, hence, cultural management strategies have to explored to manage the weed.

- It has been shown that NPV and Bt can be viable alternatives to chemical insecticide use. Thus, it would greatly benefit onion farmers who are dependent on chemical insecticides for control of cutworm. Direct effects are reduced pesticide use, better health of farmers, and sustainable *Spodoptera* management. In addition, farm-produced NPV will cut down on cost of crop protection by farmers. As a result, the market quality of their onion produce will be greatly enhanced by their low insecticide residue levels, thereby meeting the export requirements of foreign markets.

- The impact of our study shows the great possibility of drastically reducing, if not totally eliminating, insecticide use in eggplant fields, by replacing it with properly timed removal of damaged shoots and fruits, together with the already existing sanitation measures (disposal of damaged fruits from the field) which the farmers are assumed to be doing now, along with the harvesting schedule of farmers. Where before, insecticide spraying could be as high as 40 times in a 5-month crop, it is now possible to reduce it to 7 times (every three weeks). In this regard, the effect is tremendous in terms of improved environmental quality and savings attributed to insecticide use. The labor costs of removal are eventually incorporated into the labor cost for harvesting.

- Correlation studies showed that leafhopper counts, leafhopper damage rating, fruit yield and trichome density are good and reliable parameters. Jackpot, a commercial variety, is considered tolerant because it yields high in spite of the higher leafhopper damage at vegetative stage. The use of resistant or tolerant eggplant varieties is a promising alternative to reduce crop loss, increase farmer income and reduce pesticide use as shown by the differential varietal responses of several eggplant varieties against the leafhopper.

- The potential of non-chemical management strategies like plant antagonists, biological control agents, and animal manure against nematode, pink root and bulb rot pathogens were identified. The use of antagonists against damping off pathogens may be feasible with the discovery of *Trichoderma* species that are very effective and suppressive. While we understand their limitations these biological control agents should be tried in the field especially during the seedling stage of onion. Their use should compliment the use of chemicals. Continued efforts must be made in discovering other antagonists especially from

other organic waste materials and in soil rich in organic matter.

- Our study showed that planting non-host crops of *Phoma terrestris* in rotation with onion can significantly reduce the disease pressure resulting in low incidence and severity of pink root infection. However, crop rotation did not seem to be effective against the root-knot nematode.

Bangladesh

- Baseline data are required to understand the suite of socio-economic factors that influence crop production patterns and practices, pest perceptions, pest management practices and potential constraints to IPM adoption. These data can be used to compare practices of different sites, which can be useful for planning and targeting of extension and training efforts. These data can also be used to retrospectively assess the project impacts. The findings of the survey contributed to understanding of the incidence pattern and status of pests attacking rice and winter vegetables in rice based vegetable cropping systems. The results also helped to identify some appropriate researchable issues in order to develop management technologies.

- Our overall results so far indicate that the test eggplant varieties we have tested possess genetic variability for resistance /tolerance to bacterial wilt, root-knot nematode and fruit and shoot borer. Test of traditional and exotic varieties against these pests may lead to the identification of resistant sources, which may be used for developing agronomically acceptable resistant varieties.

- Results so far obtained suggest that the lure traps can capture considerable number of cucurbit fruit flies and thereby reduce the natural populations of fruit flies. Using this technique the use of chemical pesticides can be greatly minimized, which will ultimately contribute to production of healthy, pesticide free cucurbits.

- Our results showed that farmers adopted weed control measures to keep their okra fields free of weeds without considering the crop growth stage when weeding was most critical to minimise yield loss. As a result, frequent weeding operations increased the cost of cultivation. On the other hand, two hand weeding at 15 and 35 days after planting, which coincided with the critical active growth stage of the crop effectively controlled the weeds, minimised weeding cost and produced satisfactory yield that brought about better economic returns.

- Our first season experimental results also showed that, among the various soil amendment treatments and chemical control, soil incorporation of mustard oil-cake in eggplant field can effectively minimize nematode infestation and plant mortalities due to the infection of various soil-borne diseases, and can produce higher yield. This will also help to reduce the residues of chemical fungicides in the food chain.

- Soil incorporation of poultry refuse alone or in combination with fungicide and nematicide applications can effectively minimize leaf blight and nematode infestation and can promote the growth of bunching onion producing significantly higher yield. Since poultry refuse is abundant and much cheaper, farmers can use it to obtain more profits from the cultivation of bunching onion. Sawdust burning and soil incorporation of poultry refuse + sawdust burning in cucumber planting beds were highly effective in reducing pre- and post-emergence deaths of cucumber seedlings, promoted the growth of cucumber plants and produced 1.5 times more yield. This practice can reduce pesticide use minimizing its residues in the food chain.