IPM CRSP Annual Highlights

For Year 9
(2001 - 2002)

Management Entity:
Office of International Research, Education, and Development
University Outreach and International Affairs,
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Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

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IPM CRSP US Institutions

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

Host Country Institutions

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

International Centers

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

Private Sector

The Kroger Company
PICO
Caito Foods

NGOs/PVOs

CLADES; GEXPRONT, Guatemala; CARE, Bangladesh

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The purpose of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) is to develop and implement a replicable approach to IPM that will help reduce: 1) agricultural losses due to pests; 2) damage to national ecosystems; and 3) pollution and contamination of food and water supplies. The goals of the CRSP are to develop improved IPM technologies and institutional changes that will reduce crop losses, increase farmer income, reduce pesticide use, reduce pesticide residues on export products, improve IPM research and education program capabilities, improve ability to monitor pests, and increase the involvement of women in IPM decision making and program design.

Working towards this goal, the IPM CRSP follows the following specific objectives:

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

The research activities of the IPM CRSP are based on close collaborations between scientists of the participating host countries and US institutions. The participating host country sites of the CRSP during Year 9 included Albania, Bangladesh, Ecuador, Guatemala, Honduras, Jamaica, Mali, The Philippines, and Uganda. Among the active partner US institutions are: University of Georgia, Montana State University, Ohio State University, Penn State University, Purdue University, U.C.-Davis and Riverside, North Carolina A&T University, Florida A&M 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 9 of its operation. The main part of the report is a presentation of the CRSP's activities by its main regions: East and West Africa, Central and South America, the Caribbean, South and Southeast Asia, and Eastern Europe. For each active site in a region, this document gives a description of the collaborative program, the IPM constraints addressed, selected research accomplishments, progress made in training and institution building, and networking activities. The remaining sections of the report cover several major activities of the CRSP such as the Board of Directors Meeting, Technical Committee Meetings, External Evaluation Panel Reviews, Trip Reports, and Technical Assistance. Details on each of these topics and other related items can be found in the institutional reports of the Year 9 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 9 were:

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

Coordinator); Bouréma Dembélé, IER (Site Administrative Coordinator).

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

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

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

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

Southeast Asia Site in the Philippines: Sally Miller, Ohio State University (Site Chair); Aurora M. Baltazar, PhilRice (Site Coordinator)

South Asia Site in Bangladesh: Ed Rajotte, Pennsylvania State University (Site Chair); Rezaul Karim, IRRI Dhaka (Site Coordinator)

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

In the Management Entity the following contributed to the report:

S.K. DeDatta, Principal Investigator of the IPM CRSP, Director of the Office of International Research, Education, and Development (OIRD), and Associate Dean of the College of Agriculture and Life Sciences, Virginia Tech.

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

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

Keith M. Moore, Interim Associate Program Director, IPM CRSP, Virginia Tech

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

AFRICA REGION

East Africa Site in Uganda

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

The Collaborative Program

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

The IPM CRSP team in Uganda consists of six co-PIs and five graduate students from MU/FA, nine co-PIs from NARO, and three extension agents, representing six separate disciplines. Collaborating with Uganda co-PIs are eight USA-based co-PIs, representing four disciplines from three universities: The Ohio State University, Virginia Tech, and Fort Valley State University. Two activities involved new collaborating scientists. The Geographical Information Systems (GIS) training program involved Drs. L. Grossman and A. Roberts from Virginia Tech and a seminar and field-training effort on Gender Roles involved Dr. C. Harris, Women In Development specialist from Virginia Tech. Two additional changes in site team composition were the addition of Dr. Twaha-Lule, Entomologist with the Maize Research Team at NAARI, and the departure of Dr. Brhane Gebrekidan, IPM CRSP Program Director at Virginia Tech and Uganda Site co-PI. The Site Chair, Dr. Mark Erbaugh, The Ohio State University, coordinates this multi-institutional and disciplinary program.

Throughout the year, site management is facilitated by weekly contact between the Site Chair and Coordinator and all co-PIs are encouraged to maintain regular communication on individual research activities with respective collaborating scientists. The planning of the IPM CRSP program in Uganda follows a now regular sequence of meetings that seeks to maximize interdisciplinary and multi-institutional collaboration, integrate research findings, and provide consistent contact between Site managers and collaborating co-PI’s. Year 9 planning activities began with a one-day meeting held on March 1, 2002, of five social scientists affiliated with the project. This was followed by the annual work plan development meeting held in Jinja, March 7-9, at which 21 Uganda Site co-PIs and graduate students and five USA-based co-PIs attended. At this meeting, brief progress reports were presented, priorities for the next year discussed, and draft work plans for Year 9 were developed. One new activity

conducted at this meeting was break-out sessions by focal crops to assemble fact sheets that addressed priority pest and disease constraints. Following the planning meeting, a special meeting was organized to designate responsibility for planning the IPM Conference for Sub-Saharan Africa. The Year 9 draft was discussed with the Director General of NARO, USAID/Kampala, and the Chief of Party of the USAID funded Investing in Developing Export Agriculture Project (IDEA). A final draft of the work plan and budget was presented at the IPM CRSP Annual Meeting, held at Virginia Tech on May 15-19, 2002. Drs. Kyamanywa and Bigirwa from the Uganda Site attended the Annual Meeting. In most years, the calendar of events is concluded with an Annual Report Preparation Meeting, however, this year the IPM Conference for Sub-Saharan Africa, held in Kampala on September 9-12, replaced this meeting.

The Site Coordinator administers the implementation of field research activities with local co-PIs and extension agents during Uganda's two rainy seasons: the longer season roughly extends from April through early July, and the short rains extend from September through December. Linkages with local extension agents have facilitated the implementation of a farmer participatory approach to integrated pest management (PIPM) technology generation and transfer. They provide scientists, co-PI's and graduate students with the necessary linkages to local communities and farmer groups. The number of farmer groups has been expanded to five each in Kumi and Pallisa districts and four in Iganga district. The site continues to cooperate with an informal grouping of tomato growers in Mpigi District. In turn, extension agents work with NARO and Makerere scientists in the conduct of on-farm research and specialized technology transfer activities.

Finally, planning and support for IPM CRSP activities in Uganda continues to involve communication and collaboration with USAID/Kampala; the IDEA Project; the Rockefeller Foundation through the Forum on Agricultural Resource Husbandry; germplasm exchanges with AVRDC, IlTA, CIP, ICRISAT/Malawi, and CIMMYT/Harare; and several collaborative interactions with ICIPE. The IPM CRSP, ICIPE, NAARI's Biological Control Unit and Maize Research Team, and Makerere University scientists combined to provide financial and technical support for MU graduate student Ms. Teddy Kauma to rear, release and monitor the introduced parasitoid *Cotesia flavipes.* Co-PI Dr. R. Pratt continues to coordinate research efforts to determine molecular marker-assisted selection procedures for improvement of maize disease resistance with scientists from CIMMYT/Harare, the Grain Crops Research Institute in South Africa and NARO's Maize Research Team. This collaborative effort was the recipient of a special biotechnology research award from the IPM CRSP ME. USAID/Kampala continues to provide funding support with a match from the IPM CRSP ME to investigate the etiology, epidemiology and integrated management of coffee wilt *(Fusarium xylarioides).* Also, $65,000 was raised from 12 different donors by the Ugandan Organizing Committee to support the IPM Conference. Research collaboration with the Rockefeller Forum provided opportunities to cost share outreach activities and five graduate student activities through Makerere University.

IPM Constraints Addressed

The primary IPM constraints addressed at the Uganda Site are 1) poor linkages between research scientists and farmers; 2) A lack of alternatives to multiple applications of chemical pesticides, particularly for important legume crops such as groundnuts and cowpea in Eastern Uganda, but also for important

horticultural crops including tomatoes and potatoes; 3) research fragmentation caused by insufficiently integrated research activities of multiple institutions and disciplines; and 4) limited distribution and dissemination of IPM technologies.

In order to address these constraints, the Uganda Site has implemented a participatory approach to the conduct of IPM research. The initial field PA held with farmers at research sites in Iganga and Kumi Districts in 1995, and now verified by two baseline surveys, identified priority crops and pests. This helped orient research to solving farmer problems (i.e. demand driven activities). Subsequent activities including farmer field pest monitoring, farmer open days, and on-farm trials added to or amended pest and disease priorities. Priority insect pests and diseases by crop being addressed in the IPM CRSP research program are as follows: **Cowpea**, cowpea aphid *(Aphis craccivora)*, cowpea flower thrips *(Megalurothrips sjostedti)*, *Maruca* sp. pod borers, and *M vitrata*, pod sucking bugs and the bruchid beetle *(Callosbruchis chinesis)*; **Groundnuts**, groundnut rosette virus disease *(Arachis hypogaea* L.), aphids *(Aphis craccivora* Koch the vector of rosette disease), Cercospora leaf-spot *(Cercospora arachidicola)*, the groundnut leaf miner *(Aroarema modicella)*, foot rot *(Sclerotium rolfsii)* and thrips *(Thrips palmi* Kamy, *Frankiniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus)*; **Maize**, stalk borer *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae), Gray leaf spot (*Cercospora zeae-maydis)* and termites *(Macrotermes, Pseudacanthotermes* and *Microtermes)*; **Sorghum**, stalk borer *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) and the parasitic weed, *Striga*; **Tomato**, late blight *(Phytophthora infestans)*, bacterial wilt *(Ralstonia solanacearum)* and thrips *(Thrips tabaci* and *Frankliniella* sp.); **Potato**, late blight *(Phytophthora infestans)*; **Maize and Groundnut** moulds and mycotoxins *Aspergillus, Fusarium, Rhizopus* and *Penicillium* species; and, **Coffee**, coffee wilt *(Fusarium xylarioides* (telemorph = *Gibberella xylarioides*). Researcher inter-actions with farmers also suggested component technologies that have been integrated into trials. Local farmers suggested the interplanting of *Celosia argentia* with sorghum, and the use of cotton in rotation, to reduce the incidence of *Striga* and the use of several locally available bio-rational products in post-harvest storage to reduce bruchid damage.

The Year 9 work plan is organized into six topical areas that address these constraints: (1) Developing IPM packages for important legume (cowpea and groundnuts) and cereal crops (maize and sorghum) with transition farming systems in Eastern Uganda; (2) Developing IPM packages for tomato and potato, which are high-value horticultural crops. The development of pest management alternatives for both legume and horticultural crops is particularly important because the production of these crops is associated with excessive use of pesticides; (3) Determining the effects of harvesting techniques and on-farm processing on incidence of moulds and mycotoxins on maize in order to develop appropriate post-harvest disease management options; (4) Conducting socioeconomic assessments of crops and technological packages that have not yet been evaluated, including a tomato marketing assessment and an adoption study of IPM packages for cowpea and groundnuts; (5) Developing and disseminating IPM informational outputs for the IPM CRSP Uganda Site; and, (6) Examining the etiology, epidemiology and integrated management of coffee wilt *(Fusarium xylarioides* (telemorph = *Gibberella xylarioides*). This is an affiliated activity with funding from USAID/Kampala and the IPM CRSP Management Entity (ME). Additionally, the Uganda Site planned and

hosted an IPM Conference for Sub-Saharan Africa and a GIS training session.

Institution Building

According to Dr. Joseph Mukiibi, the Director General of NARO, "The IPM CRSP has played a critical catalytic role in galvanizing support for and institutionalizing IPM research and dissemination efforts in Uganda and at NARO." Approximately, 53% of the total Uganda Site budget was allocated to Makerere University and NARO. One of the main contributions to institution building by the IPM CRSP Uganda Site has been in human resource development. Graduate student training at Makerere University has helped facilitate domestic and international institutional collaborations and has contributed to research output. Fourteen Ugandan graduate students have completed or are in the final stages of completing their MS degrees. The CIAT, CIP and IITA programs in Uganda have each hired one of these graduates. One has accepted a job with the newly created National Agricultural Advisory Service, three are pursuing doctoral degrees at international institutions, and two are pursuing doctoral degrees at Makerere. Two Ugandans participated in short-term (two-month) training programs in the United States at The OSU Agricultural Research and Development Center (OARDC). Dr. Georgina Hakiza, a co-PI Plant Pathologist with CORI, worked in the laboratory of Dr. Sally Miller with Ms. Melanie Ivey learning techniques and typing different strains of *Fusarium xylarioides.* Miss Mildred Ochwoh, a Ugandan graduate student, worked in the laboratory of Dr. Sophien Kamoun on the characterization of potato late blight *(Phytophthora infestans).* Several students are also pursuing graduate degrees in the USA. Ms. Jackie Bonabana is pursuing an M.S. degree in Agricultural Economics at Virginia Tech; Mr. Godfrey Asea is pursuing a PhD. in plant breeding at The OSU; and Mr. A. Kaaya is taking course work in food safety at Virginia Tech.

There were 14 trips made to the Uganda Site this year by USA based co-PIs and IPM CRSP administrators. The OSU Vice President for Agricultural Administration and Chairman of the IPM CRSP Board of Directors Dr. Bobby Moser, and Site Chair Dr. Mark Erbaugh visited the Uganda site in early November. In late January, graduate student J. Bonabana returned to Uganda from Virginia Tech to begin her data collection activities for her thesis. In mid-February, Drs. Larry Grossman and A. Roberts conducted a three-day workshop on GIS applications to IPM in Uganda. Drs. Taylor, Warren, Luther and Erbaugh attended the annual work plan development meeting in March. At this same time, Drs. Taylor and Erbaugh worked with social scientists on data collection and analysis and participated in IPM conference organizing activities. Also, Drs. Warren and Erbaugh worked with scientists at the Coffee Research Institute and Dr. Luther continued his collaborative effort with Dr. Kyamanywa and a Makerere University graduate student on the identification and biology of beneficial insects on cowpea and groundnuts. Drs. Kyamanywa and Bigirwa attended the Annual IPM CRSP meeting held in Blacksburg, Virginia. In early July, Dr. C. Harris, Women In Development specialist from Virginia Tech, conducted a seminar and field-training effort on Gender Roles. Dr. George Mbata from Fort Valley State College went to Uganda in early August to initiate work on integrating biological controls of bruchids. Mr. Kaaya left Uganda to begin his course work at Virginia Tech in mid-August. Attending the IPM Conference for Sub-Saharan Africa were the following: IPM CRSP Principal Investigator Dr. S.K. DeDatta, Site Chair M. Erbaugh, and Co-PI's Pratt, Hammond and Ivey.

Networking

Networking is facilitated by the functional links between the Site and Deputy Site Coordinators and their respective organizations, and close communication with the Site Chair. These linkages are reinforced by visits made by USA based co-PIs, usually in the company of the Site Chair and Coordinator, to the Director General of NARO, the Dean Faculty of Agriculture and the Directors of participating research institutes. Preliminary research results are presented by co-PIs at annual meetings held in Uganda. Visits by the Site Chair always include update meetings with USAID/Kampala and other USAID sponsored efforts such as IDEA and ACDI/VOCA. Regional networking is conducted via electronic communication, research collaborations, and participation in professional societies and symposia. Formal research collaborations with ICIPE and the Rockefeller Foundation focus on mutual contributions to graduate student training and advising. Direct communication between Uganda co-PIs and USA co-PIs have resulted in germplasm exchanges with AVRDC, IITA, CIP, ICRISAT, the USDA potato research program, and CIMMYT/Harare. Functional links with extension agents and farmer NGO groups are maintained to promote IPM and technology transfer.

In past years, regional networking was promoted through the participation of co-PIs in regional fora, including the All African Crop Science Society, the International Association for Farming Systems Research, the Rockefeller Forum, collaborations with ICIPE, the Gray Leaf Spot Collaborative Network and Africa Link. In addition to these activities, this year's special networking activity was the IPM Conference for Sub-Saharan Africa, which was attended by over 190 people, from nearly 20 different Sub-Saharan countries, six European and North American countries, and four CG Centers, including CIP, IITA, CIAT, and ICIPE. In addition to the IPM CRSP, the Rockefeller Forum, ICIPE, UN/FAO, Dutch Government, USAID IDEA Project, NARO and Makerere University helped support the conference. One hundred and forty papers were presented and 50 posters were displayed. Thirty-two papers were presented by IPM CRSP Uganda Site co-PI's and graduate students. Dr. Kadiatou Toure Gamby represented the IPM CRSP Western Africa Site in Mali at the conference. Dr. S.K. DeDatta, Principal Investigator of the IPM CRSP, presented a lead paper titled: "Harmonizing Food Security and Natural Resource Management through Global Research and Education." Articles about the conference appeared in local newspapers, and radio and TV segments.

Selected Research Accomplishments

1. **Cowpea**: Two of the most important pests of cowpea are thrips (*Megalurothrips sjostedti)* in the field and cowpea bruchids (*Callosbruchis* sp.) in post-harvest storage. In terms of yield and economic loss, thrips were again found to be the most important field pest for cowpea this season. The AT (Action Threshold) for treating thrips occurred at 50% flowering. For two seasons, trials have been conducted in an attempt to develop methods that control both of these pests in the field. Results indicate that the most effective strategy is to use a combination of synthetic and botanical insecticides. This combination was found to be most effective when one synthetic spray was applied at flowering and a botanical (tobacco extract) was applied at the time of plant podding.

There is a strong and positive relationship between cowpea pod pests *(Riptortus* spp., *Nezara viridula, Acanthomia* spp., *Anoplocnemis* and *Maruca* sp.) damage and bruchid *(Callosbruchis chinesis)* damage on

cowpeas during storage. As such, treatments that reduce and/or control pod damage in the field significantly lower bruchid damage during storage. The intensity of cowpea pod pest infestation in the field directly affects bruchid infestation in storage. Treatments with Ambush CY and Sumithion 50% EC recorded the least damage by pod pests. In plots sprayed with botanicals (tobacco, tagetes and tephrosia), pod damage levels were reduced but were higher than when synthetics were used. Tobacco was the most effective among the botanicals. Botanicals showed moderate effects on control of cowpea bruchid damage levels in storage, compared to synthetics with the most effective, again, being tobacco.

Farmers commonly harvest cowpea leaves for making sauce and there was a common perception expressed by farmers that this reduced the occurrence of several major cowpea pests. A second season trial seems to verify this aspect of farmer knowledge. Defoliated vs. non-defoliated cowpea had significantly higher cowpea grain yields and significantly reduced population densities of flower beetles, pod sucking bugs and *Maruca* pod larvae, but not aphids.

The effectiveness of predators and parasitoids on insect pests of cowpea and groundnut continues to be studied. Population densities of earwigs, spiders, ladybirds, *Orius* sp., syrphid larvae, and mantid prey were higher in cowpea and groundnut polycultures than in monocultures. Ladybirds and syrphid larvae predators are able to suppress population densities of aphids. *Tachnidae* (Diptera) and *Aphidius* (Hymenoptera) were the most abundant parasitoids of aphids. Chemical insecticide applications significantly affect population densities and activities of native natural enemies, leading to erosion of useful arthropod biodiversity.

2. **Groundnuts**: This economic analysis pertains to data from the second season of 1999 and first season of 2000. Igola-1 production involved high seed and post-harvest costs. These high production costs were not matched by a high price at harvest. Consequently, at the prevailing market prices, this disease resistant variety was not profitable to the farmer. Groundnut farmers who plant the local variety Erudurudu at the first sign of rains at a low plant density of 60x30cm (the current practice in the area), would increase their marginal returns by simply changing from that variety to Etesot under the same agronomic conditions. These farmers would expect to obtain Ushs12.9 from every shilling investment made in changing from the age-old groundnut variety to Etesot. Low plant spacing has a positive effect on net income (probably because there is less pest pressure in low plant populations or that pests that survive in low plant density situations cause less severe damage). In addition, early planting of groundnuts tended to produce higher net benefits than late planting (because early planting helps to ensure that the crops are harvested before pest populations peak). Because of these reasons and the fact that Igola-1 involved high production costs, the most economically promising IPM practice included early planting of Etesot variety at low planting density. However, this recommendation is likely to change as market conditions change with time.

3. **Maize**: The establishment of *Cotesia flavipes* Cameron, a braconid parasitoid of *Chilo partellus* Swinhoe (Lepidoptera: Crambidae) was monitored in 2001 and 2002 in Masindi and Kumi districts. Establishment was determined by sampling maize and sorghum fields where *C. flavipes* had previously been released by the collaborative efforts of the IPM CRSP, NARO/NAARI, and ICIPE in 1997. The rate of parasitism of

Cotesia sesamia Cameron and of *C. flavipes* varied according to stemborer species and location. A high rate of host specificity was observed in the two districts with each parasitoid species exhibiting preference for the co-evolved host, suggesting probable absence of inter-specific competition. These preliminary results show lack of competitive displacement between the exotic and indigenous parasitoids, raising the possibility that the two species can co-exist in areas where the stemborer complex occurs. The preference of *C. flavipes* for *C. partellus* and of *C. sesamiae* for *B. fusca* and *S. calamistis* shows that both parasitoids are complementary in regulating the stemborer complex. This factor is (will be) crucial in the sustainability of the biological control program.

Termites *(Macrotermes, Pseudacanthotermes* and *Microtermes)* are an increasingly important problem on maize. Previous IPM CRSP research has demonstrated that using powdered fish bones as bait increased predatory ant activity by 90% and suppressed termite damage by 54%, compared to untreated control plots. Applying baits in shallow furrows led to significantly higher ant nesting compared to surface applications. The superior performance of buried bait is probably related to the availability of suitable nesting sites (inside maize stalks) for ants in the vicinity of protein-rich foods. The production of the fish bone baits is inexpensive, does not require high input technology, and can be prepared locally and applied easily. This year's work indicates that combining intercropping with application of fish baits led to significant improvement in predatory ant activity and reduced termite damage to maize. Legumes used in the intercrop were cowpea, soybean, and *Desmodium*. Termite attack was lower in the maize/cowpea and maize/soybean intercrops than in maize intercrops with *Desmodium*. This observation was probably related to maturity time and to the amount of foliage litter shed over the growth period of the different legume species.

Using biotechnological techniques to identify genes for resistance to maize gray leaf spot (*Cercospora zeae-maydis)* has led to the development of molecular breeding tools through identification of SSR molecular markers. New resistance genes (QTLs) for improvement of disease resistance in Sub-Saharan maize germplasm have been identified.

Gray leaf spot (GLS [*Cercospora zeae-maydis*]) is one of the major maize production constraints in Uganda. There are seasons when epidemics are severe, thus badly affecting maize production in the country. Previous studies showed that certain farming practices carried out by farmers were associated with the observed high incidence and severity of gray leaf spot. These include planting in a field having previous stover, continuous maize cropping, intercropping maize with banana or coffee that is mulched with infected stover, and growing of susceptible varieties. It was therefore found prudent to sensitize farmers about the disease and find a way of avoiding some of the practices. A campaign to create awareness and educate farmers about maize pests and diseases, particularly GLS, was carried out in four districts. Factsheets and specimens of infected plants were used to help them understand the symptoms. Field visits to serve as practicals were made with farmers to get more insight in identifying the various production constraints and seeing for themselves the farming practices that were likely to perpetuate GLS development.

4. **Sorghum:** *Striga* is still a major constraint affecting sorghum production in Uganda. Three field experiments were conducted

during the first rains (April – August) of 2002, as a continued activity to develop novel options for the management of *Striga* in Uganda. The first experiment was to determine the effect of inter-cropping sorghum with silver leaf desmodium (*Desmodium uncinutum*) for the control of *Striga* in sorghum. Desmodium was compared with three established trap crops (i.e. Cowpea, *Celosia argentia* and Bambara nuts). The second experiment was to evaluate the efficacy of herbicide seed coating as an option to minimize the deleterious effects of *Striga* on sorghum. The country's recently released improved sorghum varieties, Epuripur and Sekedo, were treated with 0.05% of each of 2,4-D and 2,4-DB prior to planting. The third experiment was a continuation of an effort to develop an effective crop rotation system for the management of *Striga* in farmers' fields. During this period, inter-cropping sorghum with desmodium at a ratio of 2:1 reduced *Striga* emergence by 46% and increased sorghum yield by 66%. Treating Epuripur and Sekedo seeds with herbicide before planting reduced the number of *Striga* plants emerging by 50%-90%, compared to the control treatment (susceptible local sorghum variety without seed treatment). At this seventh season of crop rotation, cotton/sorghum rotation reduced *Striga* emergence by 43% compared to continuous sorghum cropping. This appears to strongly suggest that cotton, as the previous crop in a rotation, is more effective in reducing *Striga* emergence on sorghum than other trap crops.

An economic assessment was done on *Striga* management options for sorghum using 4 trap crops of silver leaf desmodium (*Desmodium uncinatum*), cowpea, *Celosia argentia* and Bambara nuts. These were intercropped with an improved sorghum variety (Seredo) in the first season of year 2001 in ratios of 1:1, 1:2, 2:1 and 2:2 in order to identify the most economically viable option to recommend to farmers. A partial budgeting technique was used to derive the most economically promising treatment. Results indicated that overall treatments involving sorghum plus desmodium in ratios of 1:1 and 2:1 recorded the highest net benefits of 317,237 and 141,829 Shs /ha., followed by sorghum with cowpea at a ratio of 2:1.

5. **Tomato:** The major production constraints of tomatoes, an important vegetable in Uganda, include early and late blights (*Alternaria solani* and *Phytophthora infestans*), bacterial wilt (*Ralstonia solanacearum*), thrips (*Thrips tabaci*), aphids (*Myzus persicae*), whiteflies (*Bemisia tabaci*), and American bollworm (*Helicoverpa armigera*). To control these pests and diseases, farmers often resort to the overuse of synthetic pesticides that are expensive, are not readily accessible, are sometimes adulterated, and may not be used correctly and in the right concentrations.

DithaneM-45 is one of the commonly used Dithiocarbamate fungicides to control fungal diseases in fruits and vegetables in Uganda. However, its application by farmers in terms of concentration and frequency is questionable, and is likely to contribute to residues above safe levels in the produce. All farmers in a study involving 10 tomato commercial growers were found to apply a concentration of DithaneM-45, which was about three to seven times the recommended dose of 2.5g/l. No farmer was found to apply the chemical on fruits after harvesting. However, there was no consistent time between the fungicide application and harvesting. For example, some farmers may apply in the morning and harvest in the evening. The frequency of application depends on the season and stage of development of the crop. Farmers were found to apply the fungicide more during the rainy

season and after fruit set than during the dry season. The levels of DithaneM-45 applied on Ugandan tomatoes have been established to be three to seven times above the recommended dose. More than 90% of retailers, depending on season, may want to see DithaneM-45 on the surface of tomato fruits before purchasing them from farmers. From these results, the doses used by farmers, the frequency of spraying and the inconsistency between spraying and harvesting are likely to increase DithaneM-45 residues in the harvested tomato fruits.

The IPM CRSP tomato program carried out an on-station trial to determine the effect of management practices on the incidence of *Phytophthora* and insect pests on tomatoes. Research trials to control tomato late blight conducted over the last four seasons indicate mulching as the best treatment for reducing late blight severity and giving the highest total and marketable yields. Tomato late blight severity is reduced by using dry grass or straw mulch, staking, and/or trellising, all of which prevent direct contact of plants with soil. These methods also help farmers reduce the number of fungicide applications during the season. Staking and trellising may also require additional material and financial resources unavailable to most small-scale tomato growers in Uganda.

To develop management options for insect pests, the IPM CRSP tomato program carried out two on-station trials, one to determine the effect of management practices (i.e., trellising, staking, mulching [dry grass], yellow sticky traps, *Metarhizium anisopliae* [a bio-pesticide], clean weeding [control] and insecticides only) on the incidence of insect pests and late blight. The other aim was to determine the relationship between thrips population and tomato yield and to establish the economic injury levels (EILs). The results of this study demonstrate that thrips have been the most important of the four pests afflicting tomatoes over this reporting period. Though there is evidence that Dithane M45 (mancozeb) can negatively affect predators and thus indirectly influence arthropod pest populations, it never significantly influenced thrips populations on tomatoes in this study. The use of *Metarhizium anisopliae*, staking, yellow sticky traps and synthetic pesticide significantly reduce thrips populations on tomato plants. Given that the use of *Metarhizium*, staking and yellow sticky traps showed potential in reducing thrips pest status on tomatoes and help in conserving environmental quality (not harmful to beneficial organisms), they could be recommended as one of the IPM tactics to be further evaluated at the farmers' fields. Results for the second experiment showed a significant negative relationship between thrips densities and varying spray schedules. There was also a strong positive relationship between yield loss and thrips density in all the growing seasons and the EIL was set at 7 thrips per 3 leaves (i.e., the point at which the benefits of preventing losses due to thrips is equal to the losses that would result if management practices were not applied).

Evaluations were carried out of *Solanum incanum, S. indicum distichum, S. macrocarpon* and *S. camphylocanthum* for resistance to bacterial wilt; the rootstocks compatibility on tomato scions; the overall growth characteristics; and the overall acceptability of the ripe tomato fruits. The results showed that the four Solanaceous rootstocks were found to be compatible with the tomato scions. However, S. *indicum distichum* and *S. macrocarpon* were more resistant/tolerant to bacterial wilt than *S. incanum* and *S. camphylocanthum.* The results also indicated that tomato scions grafted on *S. indicum distichum* and *S. macrocarpon* rootstocks exhibited better overall growth characteristics than on *S.*

incanum and *S. camphylocanthum*. Using the Hedon scale to determine the overall acceptance of the grafted tomato fruits, the fruits obtained from *S. indicum distichum* and *S. macrocarpon* grafts were more comparable to the fruits from ungrafted tomato plants than the fruits obtained from the other grafts. Among the four rootstocks tested, the *S. indicum distichum* should be developed further.

Peri-urban farmers are shifting from subsistence to agrochemical intensive patterns of production in order to keep pace with the growing demand for tomatoes. Therefore, it is important to realize that the choice is not necessarily the resource combination with the highest output. Socio-economic circumstances also influence and play an important part in improving the competitiveness of tomato enterprises. This research explored the socio-economic conditions of tomato farmers and assessed the economic potentiality of tomato production in peri-urban areas using gross margin analysis and linear programming. The study indicated that tomato farmers were nearly all young (20-30 years) males often cultivating small pieces of land (<0.5 ha), which were mostly worked on by family labor using hand hoes (67%). Most farmers sprayed twice a week to control blights and once a week to kill pests on tomato crops. One of the priority problems revealed by farmers in this study was over-dependence on expensive agrochemicals to control pests (particularly thrips in dry spells) and diseases (especially late blight under wet conditions). It also revealed that higher returns may not be attractive to smallholder farmers if they require much higher costs. A high level of fungicide sprays resulted in an economically unacceptable level of investment. Technological innovations (varietal introduction) were found to be a more cost-effective means of increasing tomato output than adding more sprays to control blights in wet weather. There could also be a need to explore trade-offs of dry season tomato production with optimal watering levels and reduced fungicide application.

6. **Potato:** On-farm trials using four potato cultivars with varying levels of resistance to late blight (*Phytophthora infestans*) were subjected to four fungicide regimes (i.e. weekly, fortnightly, tri-weekly and monitoring spray schedules). A no spray control was included. The key findings of this study are that late blight causes substantial yield losses in favorable seasons, such as during the 1999B and 2000B seasons. In such seasons, losses as high as (74%) were observed on the susceptible cultivars (Kisoro and Victoria). Host resistance plays a key factor in late blight management. As indicated above, resistant cultivars recorded lower yield losses than susceptible ones, and in less late blight prone season, as during season 2000A. There was no advantage of using fungicide spray on the resistant cultivars (Rutuku and Nakpot 3), whereas one to two sprays were still essential for the susceptible cultivars (Kisoro and Victoria). Integration of host resistance and fungicide sprays enhances late blight control and reduces the need for frequent fungicide application. Whereas three to six sprays were needed on the susceptible cultivars, only two sprays were needed for resistant and moderately resistant cultivars in late blight favorable seasons.

An economic assessment was done to determine the viability of the treatment options in regard to their associated costs and benefits. Although partial budgets drawn for different varieties indicated that frequent (weekly) fungicide sprays resulted in more benefits, the marginal analysis showed that changing from no spray to two monitored sprays pays the farmer the original investment as well as over a 250% rate for susceptible

cultivars (Kisoro, Victoria) and about a 200% rate for tolerant cultivar (Rutuku, NAKPOT 3). This suggests that monitoring disease progress in the field followed by spraying is the most economic strategy for the farmer.

Phytophthora infestans isolates were recovered from late blight infected leaf samples collected from the districts of Kisoro, Kabale, Mbale and Mbarara in the Eastern and Western highlands of Uganda in 2001. Genetic analysis for mitochondrial haplotype, AFLPs and functional genomic examination for putative avirulence genes with subsequent sequencing, clustered the Ugandan isolates together with the old, less virulent and predominantly A1 mating type clonal lineage US-1 with a genetic similarity value of 95%, thereby confirming the absence of genetic diversity within the Ugandan pathogen population. Since no genetic diversity was realized in these studies, this appears to refute the hypothesis that an introduction of virulent pathogen strains could have resulted in an increase in genetic diversity responsible for oospore production and high fungicide resistance previously reported. They also highlight the possibility of the development of fungicide resistance within the Ugandan population of *Phytophthora infestans*, emphasizing the necessity for judicious fungicide application to combat resistance.

7. **Post-harvest storage**: Previous IPM CRSP studies established the need to validate different pest management options for farmers to control moulds and mycotoxins in maize during storage. Studies were therefore carried out to find the effect of solarisation, one of the recommended practices, on moisture content, mould incidence and germination percentage of maize from farmers and traders in the Mayuge district. The highest average temperature achieved during three-hour solarisation was 74.9^{o}C. Solarisation significantly (p 0.05) reduced moisture content of kernels, but had no effect on germination percentage and mould incidence. Adult maize weevils were examined at the end of the solarisation experiment and there was 100% mortality. Thus, solarisation was very effective as a drying method but not as a method for destroying mycotoxigenic fungi in maize kernels. Although solarisation temperatures rose beyond what have been reported for mould survival, exposure time may not have been adequate for mould destruction. Mould incidence was higher in processed and stored kernels, which is most likely due to drying on bare ground, seed damage inflicted during shelling and insect infestation.

8. **IPM technology adoption**: Findings indicate that for *Striga* control technology adoption, there was a significant association between adoption of the practice and farmers' prior participation in IPM activities, training in disease control, and accessibility to farming information. Cowpea IPM technology was found to be significantly influenced by the magnitude of pest problems and the type of farmer's agricultural information source. On the other hand, groundnut technology adoption was influenced by the size of households, amount of labor available on the farm, the number of crops grown, and the variety of groundnut.

9. **IPM technology dissemination**: Using a farmer field training approach has allowed the IPM CRSP to expose 300 new farmers in Kumi, Pallisa, Mayuge and Iganga districts to IPM and crop specific IPM technologies developed by the IPM CRSP. The IPM CRSP, in collaboration with the Rockefeller Forum, have been using the farmer field training approach to increase the number of farmers exposed to IPM strategies developed for both cowpea and groundnuts. Two studies examined the impact of farmer field schools on farmer knowledge of IPM and

IPM technologies for cowpea and groundnuts. A pre and post test methodology was used to assess knowledge acquisition and retention. In both studies, more and consistent attendance was associated with more knowledge. The next phase of this work will examine the association of knowledge/awareness of IPM with adoption of technologies.

10. **Networking: Integrated Pest Management Conference for Sub-Saharan Africa**: The IPM CRSP Uganda Site Team, in conjunction with Makerere University Faculty of Agriculture and NARO, hosted a five-day Conference on IPM in Kampala Uganda, September 8-12, 2002. The title of the conference was "IPM: A Strategic Tool for Agricultural Development in Sub-Saharan Africa." Over 190 people attended the conference, from nearly 20 different Sub-Saharan countries, six European and North American countries, and four CG Centers, including CIP, IITA, CIAT, and ICIPE. In addition to the IPM CRSP, the Rockefeller Forum, ICIPE, UN/FAO, Dutch Government, USAID IDEA Project, NARO and Makerere University helped support the conference. One hundred and forty papers were presented and 50 posters were displayed. Thirty-two papers were presented by IPM CRSP Uganda Site co-PI's and graduate students. Dr. Kadiatou Toure Gamby represented the IPM CRSP Western Africa Site in Mali at the conference. Dr. S.K. DeDatta, Principal Investigator of the IPM CRSP presented a lead paper titled: "Harmonizing Food Security and Natural Resource Management through Global Research and Education". Participants from the USA included: D. Taylor, Virginia Tech, designed and set-up the Announcement and Registration Website for the Conference; and B. Hedlund, USAID/CTO was also in attendance. Uganda Site USA based co-PI's M. Erbaugh, R. Pratt, R. Hammond, and M. Ivey presented papers, chaired 5 sessions and evaluated posters.

11. **Geographical Information Systems Workshop**: This activity involved conducting a Geographic Information Systems workshop to enhance site researchers' capabilities by providing collaborating agricultural scientists in Uganda with training in using the tools of Geographic Information Systems (GIS). Sixteen agricultural scientists participated in the workshop, making it the largest GIS-training workshop ever held in Uganda. Participants came from Makerere University, the National Agricultural Research Organization (NARO), the International Food Policy Research Institute (IFPRI), and the International Center for Research in Agroforestry (ICRAF). The workshop was held in a computer lab at the African Virtual University Center at Makerere University.

12. **Coffee Wilt (*Fusarium xylarioide*s)**: Lack of knowledge on etiology and epidemiology of Coffee Wilt Disease (CWD) has undermined development of effective control measures to combat this important robusta coffee disease. Genetic Diversity - Sixteen strains of *F. xylarioides* from nine districts within Uganda were isolated from robusta coffee trees showing mild to severe symptoms of vascular wilt. These strains were characterized based on vegetative and spore morphology and vegetative growth, and by comparing DNA sequences from a portion of the translation elongation factor 1-alpha gene. DNA sequences from the Uganda isolates were further compared to those of seven *F. xylarioides* strains isolated from both robusta and arabica coffee trees grown in South Africa, Zimbabwe, New Guinea and Ethiopia. Sequence similarity for the Uganda isolates from the districts of Mayuge, Jinja, Kamuli, Hoima, Mubende, Masindi, Mukono and Bushenyi was 100%. Uganda isolates from the district of Iganga were only 46% similar to the isolates from the other districts

but were 100% similar to each other. Breeding programs will need to consider the genetic diversity present in the Ugandan and the South African isolates when developing resistant varieties. Epidemiology studies found that disease incidence increased at CORI following rainy seasons and increased temperatures. Pathogenesis studies found that germination rate of coffee seeds was tremendously curtailed by coffee wilt disease. It also has been found that the *Fusarium xylarioides* can be transmitted through infected leaves and running rain water.

West Africa Site in Mali

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

The Collaborative Program

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

The IPM CRSP Project in Mali is supervised by two coordinators. Dr. Kadiatou Touré Gamby, Head of Fruit and Vegetables based in Sotuba, ensures the scientific coordination of the project, and Dr. Bouréma Dembélé, Scientific Director for IER and Head of the Weed Science Program, ensures the administrative coordination of the project. The coordination of IPM CRSP activities at the research station of Cinzana (CRRA/Niono) is carried out by Mr.

Mohamed N'diaye, Entomologist for Millet and Sorghum, and Mr. Sériba Katilé, Plant Pathologist for Millet and Legumes. The IPM CRSP collaboration with *OHVN* is ensured by Mr. Issa Sidibé, Section Head for Research and Development Linkages. *OHVN* works with the private sector in production and marketing of export horticultural crops, including green beans exported to France and hibiscus exported to Senegal, Germany, and the United States. Pesticide residue evaluation activity for exportable products (green beans, tomatoes), financed by the USAID Mission in Bamako, is conducted in collaboration with the Toxicology Laboratory of *LCV* under the direction of Dr. Halimatou Koné Traoré. *LCV* is taking the lead in developing a Quality Assurance System for horticultural produce. *ISFRA* provides training for master's students working on IPM CRSP project activities.

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

In IPM CRSP Year 9, the fourth year of Phase II, the Mali Site has consisted of participatory on-farm research on IPM technologies for the management of disease and insect pests of the two most important peri-urban horticultural export crops (green beans and hibiscus) and the most important domestic crop (tomato). In the first years of Phase II research on horticultural export crop pest management, IPM components were developed independently to provide the basis for subsequent combination into packages that address different pest problems simultaneously. This research is complemented by on-station research on biological control of the key insect pests of hibiscus, and the conclusion of innovative approaches to management of *Striga* parasitic weed on millet and sorghum, the principal cereal crops of Mali. The second stage of Phase II research focuses on the testing of pest management techniques as integrated packages, and the third stage involves disseminating farmer-tested IPM packages for each horticulture crop in the program. Viral problems in tomatoes arising in many producer villages has returned researcher emphasis to stage one priorities for tomatoes testing virus resistance varieties and identifying improved plant protection practices.

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

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

Technology Transfer

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

The IPM CRSP has collaborated with FAO in the development of didactic materials designed for extension agents and farmers through technical and financial support. For improved diffusion of the technologies developed, the IPM CRSP also collaborates with *PRONAF Mali* (*Project Niébé Africa*), which is financed by the *International Fund for Agricultural Development (FIDA)*, in using the Farmer Field School concept. During this past year, farmer field schools have been conducted with farmers in the villages of Dialakoroba, Dienfing, Koren, Kondialan, Sanambélé, Kola, Dama, Niazana, Banakoro, Tamala, Maraka, and Dafara.

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

IPM Constraints Researched

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

At the mid-point of Phase II, Farmer Field School collaborators and non-collaborators in each of the original five targeted villages were asked to participate in a Participatory Assessment (PA) of green bean production practices in their villages. Many changes have occurred since the early years of producing green beans. Recently, IPM CRSP on-farm trials and the FFS have introduced the use of neem leaf extracts, colored sticky traps, cabbage residues, and well-decomposed manure. Despite positive results obtained with the introduction of these improved technologies, certain problems persist. Among the most frequently cited constraints identified during the Participatory Assessment were: (1) the lowering of the water table of the wells, which decreases the potential for increasing production; (2) attacks of birds, which damage pods causing significant losses

of production; (3) the problem of acquisition of certain inputs, such as plastic mulching covers and petroleum jelly; and (4) delay in the payment of the producers.

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

Constraints for two other important peri-urban horticultural crops (tomato and hibiscus) have been diagnosed. For tomatoes, the major constraints identified have been diseases attacking the plants and the fruits: viruses, *fusarium*; soil borne diseases; fungal and bacterial diseases due to *Pseudomonas*; and insects, such as whiteflies (*Aleurodes*), virus transmitting insects, whiteflies (particularly in nurseries), and *Heliothis armigera*, whose larvae attack the leaves, buds and flowers. Crickets and grasshoppers are also very dangerous in the nurseries, leading to delays in replanting. The most important constraint, however, has been the Tomato Yellow Leaf Curl Disease (TYLCD) and bacterial wilt. The combination of these two diseases has brought whole villages to cease production of tomatoes.

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

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

Institution Building

The human resource development strategy prepared for the West Africa Site is long-term in perspective, assuring a breadth of skills and capacities available for IPM research into the future. This multi-faceted program depends on the *University of Mali* for the training of two master's degree students in weed science and economics/sociology, and a Ph.D. student in entomology. Alfousseini Ba completed his masters degree in socio-economics at *ISFRA* under the direction of Sociologist Dr. Denis Dougnan, in collaboration with Mrs. Penda Sissoko Sow, Economist, CRRA/Sotuba, and Dr. Keith M. Moore, Sociologist, OIRD/Virginia Tech. Mountaga Kenyatao has completed his masters degree at *ISFRA* under the direction of Dr. Bouréma Dembélé, Weed Scientists at IER, and Dr. Hess, pathologist, ICRISAT. Moussa Noussourou has just begun working on his Ph.D. program under the direction of Dr. Rick Foster, Entomology/Purdue. Bright Abonuhi, a Ghanaian student, is completing a masters degree in economics at *North Carolina A&T.*

The Farmer Field School Program focused again on green bean production for export and involved the training of 103 men and 179 women farmers in 18 classes in 12 villages. The training was led by previously trained IER and OHVN FFS trainers and seven farmer-trainers (from last year's crop of trainees, including one woman).

Short-term training in the U.S. involved Aissata Théra (virology) for three weeks at *UC-Davis*, Mamadou Ndiaye (entomologist) for two weeks at *Purdue*, and Moussa Ndiaye (weed scientist) for three weeks at *Virginia Tech*. For the third year in a row, a month-long training for two scientists of the *EQL* was conducted at the Pesticide Residue Laboratory at *Virginia Tech*.

Institutional strengthening is reinforced by frequent opportunities for one-on-one collaboration in the planning and conduct of research activities. Eleven trips were made to Mali by U.S. scientists to collaborate with *IER* and *LCV* scientists and *OHVN* collaborators on issues including analysis of tomato producer survey data (Dr. Moore), assessment of weeds in peri-urban horticulture (Dr. Westwood), drafting entomology papers (Drs. Foster and Dunkel), gender analysis (Dr. Harris), marketing chain analysis (Dr. Moore), toxicology laboratory development (Drs. Mullins and Cobb), and quality control assurance and pesticide usage and application (Drs. Mullins and Hipkins).

On the Malian side, seven visits were made to the U.S by Malian scientists. Dr. Gamby and Issa Sidibe visited the U.S. for the annual planning meeting and discussions concerning the development of a pesticide safety program for horticultural farmers. Aissata Théra, Mamadou Ndiaye, and Moussa Ndiaye worked on virology, entomology and weed science, respectively. Drs. Traoré and Dem participated in training at the Pesticide Residue Laboratory at *Virginia Tech* and Moussa Noussourou spent six weeks in the English Language Institute at *Virginia Tech*.

The Malian Government supports *IER's* IPM Program by paying salaries of the researchers and technicians, and supplying equipment and supplies (vehicles, offices, laboratories and experimental fields, etc.). Additional support for institution building has come from the IPM CRSP in the form of two computers for the socio-economic and weed programs at the CRRA/Sotuba research station of *IER*. In addition to this material support, the IPM CRSP has made an important contribution to research in Mali by establishing and maintaining a strong multi-institutional and pluri-disciplinary team in collaboration with farmer associations.

Networking

The core mechanism for in-country diffusion of research results depends on the relationship between *IER* and *OHVN* in the peri-urban horticultural regions. This relationship is built on the work of *IER/OHVN* liaison officer, Issa Sidibe. The network extends from farmers in the peri-urban horticultural regions through field agents to scientists (Pat Hipkins, John Caldwell, Mme Gamby, and Moussa N'diaye). Dr. Dunkel is developing collaborative relations with the *US Peace Corps-Mali* (Ag Sector) and *World Vision-Mali* (Bla Region) as a means for transferring Phase I IPM CRSP technologies to farmers.

IPM CRSP research results have been presented at the Regional Technical Committee (CTR) meeting at Sotuba (May 2002), at the Regional Users Committee (CRU) meeting at Sotuba (March 2002) and to the IER Program Committee (June 2002). Site Coordinator Mme Gamby was invited to participate in the International Integrated Pest Management Symposium in Uganda

(September 2002). Research results were also demonstrated during the IER Field Day at Cinzana Agricultural Research Center in October 2001.

Pesticide safety education efforts included a two-day pesticide safety Training-of-Trainers workshop for FFS trainers, as well as the delivery and evaluation of instructional materials, lesson plans and hands-on demonstration materials. Topics presented at the training session included an overview of pesticide safety, small group workshops, and a demonstration of pesticide handling and exposure. In addition, the participants assessed lesson content and presentation styles with regard to what modifications, if any, should be made before using them to instruct Malian farmers. Workshop participants included representatives from the *Institut d'Economie Rurale's* CRRA/Sotuba, the *Office de la Haute Vallée du Niger* (OHVN), and *Direction Générale de la Réglementation et du Contrôle* (DGRC). There is considerable demand for extending this training for the DGRC.

Regional networking is built around several foci. Dr. Moore met with Amadou Diarra of the *Institut du Sahel (INSAH)*) to discuss farmer and vendor training in safe pesticide use and IPM technology for horticultural export production. Diarra is the *CILSS* liaison for harmonization of pesticide use. Dr. Traoré is maintaining contacts with Dr. Abdoulaye Niassy, *DPV/Sénégal* and the USAID/Washington-funded Biopesticide Development Project. Through contacts with the USAID mission-funded *Centre des Agro-Entreprises (CAE)*, the *EQL* is also extending its network. Dr. Traoré has continued collaboration with Dr. Ardjouma Dembélé of *LABECO* in Ivory Coast, particularly in terms of developing improved supply sources for laboratory chemicals.

Research Accomplishments

Green Beans. The results of the studies comparing the integrated IPM package of technologies with that of current farmer practice show that the IPM program provides insect control, plant growth and yields that are comparable to or better than that achieved by the farmers' practices. The IPM program involved well decomposed compost (2 $kg/2m^2$) and cabbage inoculated with a biocontrol fungus incorporated into the soil, plastic mulch applied prior to planting for solarization, water applied to plots only once per day, red vaseline covered traps set out at crop emergence, blue traps set out at the vegetative stage, yellow traps set out at flowering, and up to three applications of neem leaf extract if necessary during vegetative growth, at the flower bud stage, and during flowering and pod formation. It was hoped that the reduced reliance on chemical pesticides or mineral fertilizers would not adversely affect the yields or quality of green beans produced. These results show that farmers may actually produce higher quality green beans with larger yields without the use of chemical pesticides. This system will allow farmers to continue to profitably produce green beans and still meet the demands for pesticide residue-free produce.

- IPM treatments in green bean production had insect densities and damage levels that were consistently equal to or lower than those in the farmers' practice plots.
- IPM treatments in green bean production had growth rates and yields that were more than 10% higher than in the farmers' practice plots, with a reduction of four to five pesticide applications per season.

Hibiscus. Data comparing hibiscus varieties show that the Vinto variety is able to tolerate considerable defoliation with no effect on

yield. This tolerant variety has promise for incorporation into an IPM program. Decis and neem were both effective at reducing *Nisotra* numbers and damage.

- The variety Vinto was shown to be tolerant of *Nisotra* feeding damage and shows promise for inclusion in an IPM program.
- Low to moderate levels of *Nisotra* feeding damage had no impact on hibiscus yield, indicating that substantial populations may be tolerated without any economic loss.

Tomatoes. The impact of the whiteflies and the viruses they transmit has been sufficient to change Mali from a tomato exporting country to a tomato importing country. The research results achieved thus far have not solved the problem. Foliar sprays did not reduce the number of aphids, percentage of plants with virus symptoms, or percentage of dead plants. All treatments reduce the percentage of rotten fruit and fruit damaged by borers. Plants protected with netting had higher yields than any other treatments, but there were no other significant differences. Seed treatments did not reduce the percentage of plants with aphids, virus symptoms or dead plants. In one location, the treatments reduced the percentage of rotten fruit and damage by borers. Yields were not affected at one location, but at the other location the Fipronil seed treatment, the high rate of salicylic acid and the net protection resulted in yields that were significantly higher than the untreated control. Future research will test systemic insecticides that are more likely to control whiteflies, based on results from other parts of the world and the potential for use of resistant tomato varieties.

Samples of tomatoes and other crops and weeds were collected and squashed onto nylon membranes in triplicate in order to carry out squash blot hybridization. These membranes were probed with the following probes/stringency conditions: TYLCV (a clone of TYLCV-DO, a "typical" TYLCV from the Dominican Republic)/high stringency, TYLCV-Mali (clones representing TYLCV-Mali-see above)/high stringency and a general probe that detects whitefly-transmitted geminiviruses/low stringency. One of the samples was cassava plants showing symptoms of infection by African cassava mosaic virus (ACMV), which we would expect to be positive with the general probe but negative with the TYLCV probes. Basically, the only samples in which TYLCV DNA was detected were in tomato leaves with yellow leaf curl symptoms from Banankoro and from a farmer's field near Dafara. Samples of cassava with ACMV symptoms, peppers with leaf curl and crumple, tomatoes with mild virus-like symptoms, okra with leaf crumple and yellowing and weeds with virus-like symptoms were negative for TYLCV. This indicates that the primary host for TYLCV in Mali is probably tomatoes, which is consistent with results from other places. This also suggests that a tomato-free period could be a useful tool for TYLCV management in Mali. The results with the general probe revealed geminivirus infection in the tomatoes with yellow leaf curl symptoms and in the cassava with ACMV symptoms (as expected). Geminivirus DNA was not detected in samples of other plants.

Weed Control in Horticultural Crops. Infestations of *C. rotundus* have been a major constraint on horticultural production. In our experiments, these populations were greatly reduced by all treatments involving potash. Mixtures containing neem and eucalyptus were observed to act more rapidly on the *C. rotundus* than the simple mixture with water. We have also found that the residual toxicity of the potash in the soil persists for about six

months for all formulations, after which it is possible to replant crops.

Another mechanism for reducing levels of *C. rotundus* is to cover the soil surface with a mulch to exclude light. *Cyperus rotundus* is not tolerant of shade, so thick ground covers can be effective in reducing the populations. At the end of the rainy season before green beans are planted, large quantities of plant material are available for mulches in the garden.

- Straw mulch covering plots to a depth of 15 cm provides excellent weed control (including *Cyperus rotundus*) in green bean plots.
- Research has identified potash as an effective non-selective treatment for controlling *Cyperus rotundus* and other weeds in green beans prior to the growing season.

Gender Analysis of IPM Knowledge, Attitudes and Practices. During the 2001 growing season, a survey of Malian tomato producers in the eastern zone of OHVN (Office de la Haute Vallée du Niger) was conducted to understand the gendered conditions shaping the division of labor, decision making, information sources and use of IPM technologies. The sample draws on three groups of producers, male collaborators, and both male and female non-collaborators in the IPM CRSP farmer field trials' two villages. The division of labor and decision-making in men's and women's gardens demonstrates a certain symbiosis, as decision-making seems to be a function of labor contribution. While men's labor is quite stable across all production activities, women's labor varies both on their own plots and on those of their husbands'. Nearly all tomato producers use insecticides for pest management, two-thirds of them spraying two to three times a season. Three-quarters of producers, collaborators and non-collaborators – men and women – want to use more pesticides in order to protect their crops. Women and collaborating men are less likely to desire using more pesticides.

Village workshops aimed at eliciting the constraints on IPM adoption while simultaneously serving to sensitize their participants to gender issues demonstrated that poverty could make it difficult for IPM practices to be carried out correctly because the lack of funds to purchase seeds made the green-bean farmers dependent on middlemen who usually insisted on their spraying regularly as part of the package deal. In previous years, women's constraints on using IPM had turned out to be higher than men's, in part due to the fact that before the current reporting year women were less likely to have participated in a farmers' field school. However, this imbalance has been corrected by the establishment of women's FFS during Year 9, and some 179 women have now been trained and have adopted the IPM package.

- Impacts from the gender workshops were that more men allowed their wives to have the use of a plot for farming green beans for themselves and that they took on some tasks previously allotted to women in order to relieve them of some of their work burden.

Stakeholder Analysis. The green bean marketing chain was examined from the perspective of the exporters. Exporters are trying to establish credible relations with their peasant producers, providing inputs in advance and hoping for timely production schedules. Their chief concern is what happens to their produce once it reaches Rungis market in France. There appears to be minimal confidence in the brokers, which they must work with to sell their products.

- Much of the up front investment (and risk) in green bean production is being borne by the exporting companies who supply production inputs to farmers who may or may not produce sufficient high quality green beans to assure sales in the market in France.

Quality Assurance Program. The EQL acquired additional laboratory skills needed to maintain and operate a high performance liquid chromatograph (HPLC) with computer interface for pesticide residue analysis. Increased levels of GLP documentation and organization at the facility, including training of the staff, enhance the capabilities of the EQL.

The pesticide safety education lessons delivered to IER trainers included hands-on interactive demonstrations for eight topics, including pesticide exposure, toxicity, use of protective clothing, use of application equipment, and safe and effective handling and application techniques. Pesticides in unlabeled containers are available in the local markets, but appropriate personal protective equipment (PPE) did not seem to be available.

Preliminary tests indicate that the pH and turbidity of village well water may significantly affect the efficacy of pesticides applied to horticultural crops.

- Bringing an additional instrument on-line at the EQL expands their analytical capabilities and troubleshooting problems on-site and provides the confidence and skills needed to solve maintenance problems without ready access to technical support services.
- Pesticide applicator safety and quality assurance training was delivered to IER agents, further encouraging the transfer of pesticide safety information to horticultural producers during the farmer field schools (FFS).

Green beans produced by small-scale farmers using integrated pest management methods in south central Mali would not be rejected in the European market due to pesticide residues from Deltamethrin. However, there is a concern that because this is a major cotton production area, there are other more persistent pesticides that may be incorporated into the green beans grown in this area.

Striga Management. Results from the 2001 field season provide additional evidence for the potential of small quantities of herbicides absorbed into crop seeds to serve as a deterrent to early parasitic attachments of *Striga*. 2,4-DB continues to show promise for the reduction of *Striga* in sorghum and prosulfuron and dicamba reduce parasitism of millet. Despite these successes, problems remain with respect to toxicity of the herbicides to crops, and it is likely that alternative herbicide formulations or additional treatments will be required to balance efficacy toward *Striga* with safety for the crops. In addition to this work, significant progress has been made in a laboratory-based study to identify the general mechanism of resistance in sorghum varieties. In contrast to susceptible sorghum variety CSM 388, which induces high levels of *Striga* germination, *Striga*-resistant varieties CSN 39 and CMDT 38 appear to be low producers of the stimulant. Sorghum varieties with enhanced resistance to *Striga* are being widely adopted by farmers, and breeding efforts will be aided by this understanding of *Striga* resistance.

- Herbicides applied to seeds of sorghum and millet are potentially effective tools to reduce parasitism by *Striga*.
- *Striga* resistance in the sorghum variety SRN 39 is attributable at least in part to low production of germination stimulant.

This information, along with the polybag system used to study it, will be useful to Malian plant breeders in developing *Striga*-resistant sorghum varieties.

LATIN AMERICAN REGION

Central America Site in Guatemala and Honduras

Stephen C. Weller, New Site Chair, Purdue University; Glenn H. Sullivan, Former Site Chair, Purdue University; Guillermo E. Sánchez, Site Coordinator, ICADA, Guatemala

Description of the Collaborative Program

The IPM CRSP Central American Site had an exceptionally productive program agenda in Year 9. The site operates through an active site committee structure, with Guatemala as the prime site for Central America. Dr. Guillermo Sánchez, Central American Institute for Agricultural Development (ICADA), served as the regional site coordinator for Central America. The Regional Site Committee is comprised of Dr. Sánchez, Jorge Sandoval (UVG), Ing. Luis Calderón, Danilo Dardón, (ICTA), Juan Enrique Leal (Soluciones Analíticas), Luis Alvarez (ARF/AGEXPRONT), Jorge Mario Santos (MAGA), Luis Caniz (APHIS-IS), Linda Asturias (ESTUDIO 1360), and Maria Mercedes Doyle (ZAMORANO). The U.S. researchers that collaborate with the regional site committee and provide research support, technical support, and program coordination include: Drs. Glenn H. Sullivan, U.S. Site Chair; Stephen C. Weller; C. Richard Edwards; and Ray Martyn (Purdue University); and Sarah Hamilton (Adjunct Professor-Virginia Tech). The overall Central American site activities in Year 9 were funded through U.S. IPM CRSP under subcontract with Virginia Tech, and grant funds generated from the Government of Guatemala (GOG) and ARF/AGEXPRONT.

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

Substantive discussions were carried forward with Nicaragua, and the Ministry of Agriculture in Honduras established an MOU during Year 9. ZAMORANO and Honduran Foundation for Agricultural Research (FHIA, Honduras) were the principal regional collaborating institutions outside Guatemala in Year 9.

In Guatemala, APHIS and AGEXPRONT continued to provide strong collaborations in the development of IPM/Integrated Crop Management (ICM) strategies for reducing pesticide use, increasing product quality, and improving the performances for achieving safer food supplies in the NTAE sector. APHIS-IS and MAGA (Ministry of Agriculture, Guatemala) continued to provide collaborative leadership in the development and institutionalization of preinspection programs in Guatemala. GOG grants to the IPM CRSP researchers at Universidad del Valle, ICADA and AGEXPRONT provided funds for community level research transfer activities and training, including field demonstrations. ICTA and UVG have continued to collaborate in testing and revising IPM CRSP production strategies for improved pest management in snow peas (leaf miner), tomatoes (whitefly), broccoli (*Plutella xylostella*), and papaya (papaya ringspot potyvirus). ESTUDIO 1360, in collaboration with Dr. Sarah Hamilton, contributed substantively to research activities that evaluated the socioeconomic impacts of NTAE production at the community and household levels.

IPM Constraints Addressed

Institutional policies: Science-based production and preinspection policies that lead to reduced pesticide usage and decreased product rejections at U.S. ports-of-entry continue to be the major focus for resolving some of the more important institutional constraints in Central America. In Guatemala, MAGA endorsed these efforts in Year 9 through programs and national policies that encourage substantive adoption at the national level. Private sector institutions have become increasingly supportive through the leadership of Luis Alvarez of AGEXPRONT. GOG initiatives to revise policies commensurate with the demands of a more competitive marketplace in the NTAE sector are now receiving serious consideration.

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

Technology Transfers

The IPM CRSP continued transferring biorational IPM/ICM technology to NTAE producers and field technicians in Year 9, which helps many small independent NTAE producers to reduce their reliance on chemical control practices and use of unregistered pesticides for insect and disease control. This training is gradually allowing more IPM CRSP approved pest management information to be transferred through grower workshops, technician seminars, and field demonstrations to the actual practitioners. These technology transfer and field demonstration activities will be enhanced as the GOG accelerates program initiatives in preinspection and grower certification. ICTA, AGEXPRONT, and PIPAA (Integrated Program for Protection of Environment and Agriculture, GOG) played important roles in these training and technology transfers.

Research Capacity

We now have a "critical mass" of trained field technicians who are capable of addressing pest management problems using applied science-based protocols and approved IPM/ICM practices developed and transferred by the IPM CRSP. AGEXPRONT and ICTA, in collaboration with IPM CRSP researchers, have played an important role in achieving these results. The GOG and ARF committed over $225,000 in matching funds for IPM CRSP research in Year 9. In Honduras, the Ministry of Agriculture and FAS funded a $100,000 research initiative in Year 9 titled "Identification, distribution and epidemiology of plant virus pathogens that threaten pepper/tomato and cucurbit production in Honduras and Guatemala." This research project is directed by Dr. Ray Martyn (Purdue) and Dr. M. Doyle (Zamorano), in collaboration with Drs. D. Krigsvold (FHIA), G. Sánchez (Guatemala), S. Weller (Purdue) and R. Edwards (Purdue).

The IPM CRSP capacity in socio-economic research activities was strengthened in Year 9 through the leadership of Dr. Sarah Hamilton and her collaborators at ESTUDIO 1360. Quantitative assessments of socio-economic benefits in NTAE producer households have continued to provide the excellent documentation needed for strengthening the policy and program commitments from the GOG, AGEXPRONT, and other private sector collaborators. Over two-thirds of the NTAE households surveyed reported that they had improved their quality of life since 1980, including housing, health care, education, and nutrition. NTAE earnings enabled 39 of 45 individuals surveyed to buy land, which resulted in a modest deconcentration in land distribution over the last 20 years. These findings clearly helped the GOG make positive determinations in providing funds to support the development of the first grower-based supply consolidation and preinspection center in the NTAE sector. The IPM CRSP will play an instrumental role in training and technology transfer as these preinspection centers are developed.

Research collaborations were strengthened with the U. of Georgia, AGEXPRONT, and APHIS in helping resolve the ringspot potyvirus problem in papaya. This, coupled with the IPM CRSP/APHIS supporting documentation to achieve clearance for papaya into U.S. ports-of-entry, provides the basis for significant NTAE trade expansion in the years ahead. Central America has the capacity to be very competitive in Eastern United States markets for quality papaya.

Institution Building

The Government of Guatemala, through MAGA and ICTA, continued to support the IPM CRSP's overall objectives for

strengthening scientific capacity and market-focused planning in the NTAE sector. These institutional linkages continue to be among the most important factors in moving the IPM CRSP research and development agenda forward in Central America. The continued GOG commitment provides clear evidence of the IPM CRSP's role in institution building in Central America. Institutional collaborations with FAS, APHIS, and FAO have been critically important in helping develop additional program funding and capacity for the IPM CRSP. The USAID Mission's commitment to microenterprise financing in Guatemala in Year 9 will serve as a cornerstone for the institutionalization of greater access to credit among small NTAE producers. Credit availability at the producer level has been a major constraint to NTAE expansion and the implementation of biorational production programs in years past.

In Honduras, through the Ministry of Agriculture and in collaboration with Zamorano and FHIA, institutional relationships and research capacity were strengthened with the finalization of an MOU between the IPM CRSP and the GOH, and the subsequent finalization of a $100,000 USD research grant (FAS/GOH) to strengthen research collaborations in resolving the disease problems associated with virus pathogens in NTAE crops. IPM CRSP research agendas were presented to the Ministry of Agriculture for funding in Year Eight and funded in Year 9. These research activities have begun.

The IPM CRSP in Central America continues to place high priority on strengthening the institutional capacity of collaborators and collaborating institutions. IPM CRSP scientists in the United States have given high priority to strengthening institutional capacity in research, technology transfer, and program implementation.

Student Training

Jim Julian, a U.S. citizen, is working on his Ph.D. under the direction of Dr. Glenn H. Sullivan at Purdue University. His research and training focuses on the impact of non-economic constraints to trade in the NTAE sector of Central America, including food safety and regulatory compliance issues. He will complete his degree in December 2002.

Carlos Mayen, a native Guatemalan, completed a summer internship at Purdue University in the 1999 summer term, and now is working on his Master's Degree under Dr. Stephen C. Weller in the Horticulture Department at Purdue University. His research and training is in biorational pest management strategies for Central America NTAE crops. He will finish his degree in May 2003.

Gustavo Acosta, a native of Mexico with broad experience in Central America, is completing a Master's Degree in Agricultural Economics at Purdue University on a match-funded assistantship under the direction of Drs. Kenneth Foster and Glenn H. Sullivan. His research centered on strategic market development issues for Central America in the NTAE sector. He completed his degree August 2002.

Networking

Collaborations with APHIS-IS in the development and testing of preinspection programs have helped to further expand the IPM CRSP networking activities in Year 9. This collaboration was strengthened through activities associated with USDA's formal approval of Guatemalan papaya into U.S. markets, and will allow expanded program development of the Petén Region for papaya production.

Private sector grower-shippers and shippers of NTAE crops that are participating in the IPM CRSP-led initiative became important "technology transfer agents," potentially reaching nearly 13,000 small farm producers, field technicians, and community leaders throughout Guatemala and Central America. This networking activity will continue to be important as the GOG implements regional supply consolidation/preinspection centers, and institutionalizes preinspection protocols and policies.

Networking activities at the district and community levels were expanded in Year 9 as additional households in the Chimaltenango District were surveyed in the socioeconomic assessments. Overall, the IPM CRSP has networked with over 40 communities throughout Guatemala. These collaborations serve as the basis for continuing research and outreach activities. In addition, gender and socioeconomic impact studies were conducted at the community level in Guatemala. This networking activity has greatly enhanced the socioeconomic knowledge base of the IPM CRSP, and has generated important gender, household, and NTAE impact conclusions for publication.

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

Institutional networking activities continued in Year 9 as preinspection policies in snow pea were institutionalized for implementation by the GOG. ICTA, MAGA, APHIS, and AGEXPRONT continued to play important collaborative roles in preinspection research, development, and implementation. In addition, PIPAA, a joint MAGA/private sector entity, was commissioned by the GOG to handle preinspection program implementation, compliance, and enforcement in Guatemala's NTAE sector. This important networking activity required a substantive commitment from the IPM CRSP in training and knowledge transfers.

The IPM CRSP strengthened networking activities in Honduras in Year 9. The former Minister of Agriculture, Guillermo Alvarado Downing, had requested an IPM CRSP developed research proposal to address the issue of plant virus pathogens that cause serious damage to the melon crop in Honduras. A GOH MOU was signed with the IPM CRSP. Melons, particularly cantaloupe during the period January through April, comprise Honduras' most important NTAE crop. However, plant virus diseases currently threaten nearly 11,000 acres of melon for export to the United States valued at over $24 million. The IPM CRSP, under the leadership of Drs. Ray Martyn at Purdue University and Maria Mercedes Doyle at Zamorano, responded to Minister Alvarado Downing's request for a research proposal to address these plant disease problems. The proposal was approved and the Honduras IPM CRSP collaborators received $100,000 from the GOH in Year 9.

In Year 9, the IPM CRSP hosted the 5th Seminar on Integrated Pest Management in Non-Traditional Export Crops in association with the 42nd annual meeting of the American Phytopathological Society – Caribbean Division in Antigua on June 17-19, 2002. Many NGO's, technicians, researchers, government officials, and collaborators actively engaged in the NTAE sector attended this meeting and over 30 presentations were made from IPM CRSP collaborators. This important networking activity attracted over

400 registered participants from Caribbean countries, and served as an important vehicle for reporting IPM CRSP research and transferring IPM/ICM technology throughout the region.

The IPM CRSP continued to strengthen networking activities with the University of Georgia, The National Science and Technology Council in Guatemala, and The National Papaya Growers Association in addressing the ring spot potyvirus in papaya. These networking activities will likely be expanded and strengthened in Year 10 through a stronger collaboration with researchers at the University of Georgia and additional funding.

Research Accomplishments

- Institutionalization of the GOG certified preinspection program for trade expansion in the NTAE sector, including performance protocols, supply source tracking, technology transfers, enforcement policies, and grower training, continued to serve as the "cornerstone" of all IPM CRSP related research and training activities in Year 9. IPM CRSP developed production strategies and performance protocols serve as the foundation upon which all preinspection related GOG programs and policies are established. Collectively, these collaborative research activities have helped reduce grower reliance on chemical pest control methods, improved economic returns to growers, and enhanced the socioeconomic welfare of NTAE households.

- The importance of this research accomplishment centers upon the fact that Guatemala's competitive position in the NTAE sector has suffered since 1995 due to sanitary and phytosanitary violations detected at U.S. ports-of-entry**.** An assessment of U.S. trade data suggests that there is a high correlation between the lack of compliance with the aforementioned non-economic constraints and a decline in Guatemala's competitive position in the U.S. vegetable market. Further, increased difficulties experienced by importers and exporters as a result of automatic detentions has reduced the number of U.S. importers of Guatemalan snow peas, and has increased the pressure to find alternative snow pea sources. These findings will be used to develop recommendations to enhance the competitiveness of Central American NTAE programs in U.S. markets. The IPM CRSP is playing a pivotal role in helping reestablish regional competitiveness and trade expansion in the NTAE sector. The overall IPM CRSP objective continues to center on economically sustainable NTAE crop trade expansion in Central America, with less dependency on chemical pest control methods.

- In collaboration with APHIS-IS and MAGA, preliminary assessments were conducted by IPM CRSP researchers to evaluate the potential for papaya in the U.S. marketplace. While additional quantification will be necessary, these preliminary assessments found that significant market opportunity does exist, but only for a standardized grade at uniform quality on a consistent basis. These findings further concluded that the greatest market opportunity existed for the Hawaiian (solo) type papaya in the Eastern U.S. markets. This preliminary research helped establish the basis for USDA clearance for Guatemalan papaya into the United States, and serves as the basis for serious GOG/APHIS-IS program initiatives for developing papaya

production in the Petén Region of Guatemala.

- Moreover, the IPM CRSP research collaborations with U. del Valle and the U. of Georgia addressing the papaya ringspot problems in Central America has led to potentially virus free papaya production in 2002. This research was partially funded by the National Science and Technology Council as a part of a papaya genetic transformation study to incorporate coat protein-mediated resistance into native and Hawaiian-type papayas. This research has been an important consideration in the GOG/APHIS-IS decision to target the Petén Region, an economically depressed region of Guatemala, for papaya production. Such development compliments the USDA/APHIS/GOG objectives to establish a medfly-free zone between North and South America. Medfly is a potential threat to North American producers, and is now controlled through intensive chemical control methods.

- In one of the first studies of its kind, IPM CRSP researchers in collaboration with FAO, INCAP and the GOG, began evaluating the health affects of IPM adopter households in the NTAE sector of Guatemala. This research activity builds on prior IPM CRSP research that has helped reduce pesticide applications dramatically, and upon current socioeconomic research that finds NTAE households with better health and education benefits. This study will further quantify the health status of those households that have adopted IPM/ICM technology in NTAE production, and compare the findings with non-adopter households. This progressive IPM CRSP activity serves as a significant baseline study for future research, and potentially significant levels of new funding. Dr. C.R. Edwards, Purdue University, serves as the program leader in this IPM CRSP activity and the first health fair was held on June 15, 2002.

- As previously stated, Year 9 IPM CRSP research achieved substantive validation of the socioeconomic benefits that accrue from NTAE production and IPM CRSP technology adoption. Findings concluded that adopter households generally witnessed an improved and/or more stable family economic situation, and an improved quality of life, with NTAE production and lower pesticide use. Better health care and education, as well as higher rates of more stable employment, were most commonly perceived as benefits from NTAE production. Fully, 64% of all producers surveyed responded that their socioeconomic situation overall was improved from NTAE production.

- A majority of NTAE producers reported that NTAE production had contributed to improved household economies, nutrition, education and overall quality of life. There were no gender differences in the perceived impacts of NTAE production on household economic trajectories. Both men and women reported shared decision processes concerning use of land and incomes related to NTAE production. NTAEs provided considerable employment. Most NTAE producers continue to produce crops for household consumption, a strategy that, combined with greater purchasing power and women's access to NTAE incomes, allows for positive nutritional outcomes.

- These "benefits assessments" will be expanded to a larger sample population in

Year 10, however, the benefits to our overall program in Central America are already evident. The GOG has proceeded to move more aggressively on matters that assure long-term institutionalization of IPM/ICM programs in the NTAE sector. The GOG and APHIS-IS have increased efforts to develop NTAE production in the Petén Region, with particular emphasis on papaya production for U.S. markets. The private sector, under the leadership of ARF/AGEXPRONT, has galvanized efforts to support the institutionalization of preinspection in the NTAE sector of Guatemala, and work to coordinate NTAE trade expansion with GOG policies and initiatives under an "aid through trade" coalition.

- Substantial research has been conducted in IPM strategies in our target crops of snow pea, broccoli, and tomato, with the primary objective to develop science-tested IPM programs for improved pest management, reduced pesticide use, more efficiency in pest management and with the final goal of improved markets for NTAE crops. Highlights include:

  a) Studies investigating the influence of soil management and threshold based weed management in vegetables. These studies are designed to improve long-term weed management in NTAE crops by integrating cropping practices that reduce weed seed levels in the soil seedbank, and subsequently lower pest pressure.

  b) Synthetic *Plutella xylostella* sexual pheromone traps placed on the perimeter of broccoli fields provided a higher level of control of the insect than those placed in the center of the fields. Further research is in progress to assess the impact on overall insect control and pesticide use.

  c) Previous research supported by IPM CRSP for pest control in broccoli was integrated to develop an IPM approach to pest management. These studies have been initiated in collaboration with growers to show how technologies including biofumigation, use of seedlings for transplants, use of Bt for lepidopterous larval control, timing of pesticide sprays based on population scouting, and timed fertilizer application can reduce pesticide applications and improve pest control and crop yields.

  d) Surveys are underway to determine the geographical distribution of *Plasmodiophora brassicae*, the causal agent of the disease clubroot in Guatemala. Preliminary results indicate that the disease is expanding in Guatemala into departments where crucifers have recently begun to be grown. These surveys will allow a targeting of research efforts to determine why the disease is spreading and how cultural practices are involved in the spread.

  e) Research investigating organic materials as substitutes for methyl bromide fumigation in broccoli was continued in Year 9. As previously determined, organic materials coupled with solarization have excellent potential for use as alternatives to chemical fumigation. Use of residues of wild broccoli species, and broccoli residues used with solarization resulted in reduced weed pressure, improved soil nutrient levels, and improved soil structure. These treatments will be tested further,

especially by small landholder farms where the technique has the greatest potential for adoption. Similar experiments were conducted in tomatoes by combining solarization with either chicken manure, tomato stubble, cucumber stubble or as single treatments compared to intensive chemical use. All treatments showed positive results and improved soil fertility. The chicken manure plus solarization treatment resulted in the highest yields.

f) Research was initiated to determine the potential for development of bioclimatic models for control of the diamond back moth in broccoli and leaf miner in snow pea. For the diamond back moth, research showed that population dynamics were correlated with air temperature, humidity, and rainfall. For leaf miners, population dynamics were related to air relative humidity, air temperature, and relative humidity in the leaf canopy. Continuing research in both crops will allow development of models to predict population levels for more precise and effective timing of control techniques that lead to a reduction in pesticide use.

g) Research has been initiated in Honduras to identify plant virus pathogens that threaten pepper/tomato and cucurbit production. In addition, this research will determine the distribution and epidemiology of these virus pathogens. The research has just begun due to delays in release of funds from the Honduran Government, but has already involved surveys to collect leaf tissue over two seasons in six departments of Honduras. Incidence and severity of the viral infections were recorded at each sampled field. Samples have been tested by means of a core PCR for Begomovirus in all target crops and have shown a high incidence of viral infection. Further research will utilize improved assay techniques to determine virus infection and to develop improved IPM strategies to reduce this problem.

South America Site in Ecuador

Jeff Alwang, Site Chair, Virginia Tech; Carmen Suárez, Site Coordinator, INIAP; Victor Barrera, Vice Site Coordinator, INIAP

Description of the Collaborative Program

This is the fifth year of activity at the South American site in Ecuador. A total of 12 major activities were conducted during the year. This site operates under a Memorandum of Understanding with INIAP, the research arm of the Ministry of Agriculture in Ecuador. A Site Coordinator and Assistant Site Coordinator manage activities under the CRSP because the crops included are primarily located in two locations. Carmen Suárez serves as overall Site Coordinator and focuses on the work in the lower elevations. She is a researcher at the INIAP Tropical Experimental Station at Pichilingue and coordinates plantain and agroforestry activities. Victor Barrera serves as Assistant Site Coordinator and focuses on the higher elevations. He coordinates activities with potato and Andean fruits. Each activity has a leader that is responsible for interactions with their respective coordinators and cooperators.

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

The Year 9 workplan focused on crops, pests, and constraints identified in the participatory appraisal process. Planning and collaborative research took place through: a) discussions among host country and US/international scientists at planning meetings in Ecuador and Blacksburg, VA, and b) preparation of joint host-country/US/international scientist two-page proposals.

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

IPM Constraints Addressed

The key constraints addressed in Ecuador in Year 9 were the need to identify and develop IPM solutions to specific pest problems in potato, Andean fruits, and plantain. Additionally, there was demand for information on mechanisms for diffusion of IPM technologies in potato. Specific major pests being addressed in the IPM program are Late Blight (*Phytophthora infestans*), Andean Weevil (*Premnotrypes vorax*), and Central American Tuber Moth (*Tecia solanivora*) in potato; Babaco and Narajilla Vascular Wilt (caused by *Fusarium oxysporum*) and other pathogens in Andean fruits; and Black Sigatoka (caused by *Micosphaerela fijensis*), the bacteria *Erwina* sp., and several insect pests in plantain. The work in Maquipucuna focused on identifying and evaluating IPM solutions to pest problems in a mixed coffee and plantain system.

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

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

Plantain is a staple food for people living in the littoral (lowland Tropics). In fact, plantain is a substitute for potatoes at lower elevations. The plantain research is especially important, as there has been very little study worldwide of IPM practices for plantain. It was originally assumed that many banana practices could be directly transferred to plantain, however, our research is showing that is not the case. One objective of the research in the plantain pest-survey is the identification and quantification of nematodes associated with this crop. This is the first such investigation of its kind of which we are aware.

Selected Research Accomplishments

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

A promising entomopathogenic means of controlling Andean Weevil in potato has been identified and tested in on-field conditions.

Alternative means of controlling Andean Weevil in potato through more limited use of Triflumuron have been identified and tested. This field-based study builds upon research findings from previous years, and shows significant economic gains to the farmers as well as lower health risks. Extension agents have been trained in more limited spraying of Triflumuron.

Means of controlling *Rhizoctonia solani* have been identified; this disease has been a major deterrent to the export of the *Yema de Huevo* potato variety.

Knowledge of the biological and non-biological nature of suppressive soils in control of Babaco Vascular Wilt has been developed. Such knowledge will help considerably in the management of *F. oxysporum* by reducing disease incidence and delaying development of BVW in babaco orchards, chamburo and toronche.

Pheromone attractants for *Neoleucinodes elegantilis*, an important Naranjilla pest, have been tested with some success.

The relationship between soil fertility, plant health and the population of fruit mites on Babaco is now known.

The etiology, plant resistance and seed-borne transmission of Naranjilla Vascular Wilt have been established. Control measures are now being identified; the most appropriate control method appears to be plant resistance to *F. oxysporum*.

Field-level control of *B. castanesu* in blackberry has been established. Mass-production techniques for entomopathogens have also been identified.

The main virus diseases associated with tree tomato production in Ecuador were identified.

Anthracnose is an important constraint to tree tomato cultivation in warm and humid areas of Ecuador; techniques for control strategies in farmer fields have been developed.

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

A strategy for control of Black Sigatoka in plantain has been identified. Fungicide application techniques have been investigated and a complete IPM package is available.

More information is needed before recommendations can be made for the control of Black Weevil (*Cosmopolites sordidus*) in plantain. However, the medium and container for distribution of the entomopathogenic fungi *Beauveria bassania* has been prepared for field testing. This biological control has promise in the control of the weevil.

The value of pheromone (cosmolure+1) was established as a valid method of monitoring the Banana Root Borer (banana weevil or black weevil) in plantain, and also as a method that can be used in removing them from the planting. Traps made of fresh plantain pseudostem continue to show its efficiency and should be incorporated into any IPM strategy for this insect.

Distribution and quantities of the four main parasitic nematodes affecting plantain have been established. A great diversity of parasitic and predator nematodes was identified in plantain cropping systems. This diversity seems to be playing a role in controlling pest populations. There is, therefore, a need to explore how to increase these populations in order to improve their biocontrol potential.

Farmer field schools have been established in 16 communities in Ecuador's principal potato-growing regions. IPM techniques are being disseminated by the 302 field school participants. Several workshops have been conducted and the methodology is being extended to other potato-growing areas of Ecuador.

Work in potato, Andean fruits and plantain has progressed to the point where results are now being published in international and regional scientific journals.

Mutuality of Benefits of the Research

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

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

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

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

Institution Building

Collaborative research and financial support have directly benefited institutions in Ecuador. A special issue of the technical research journal "INIAP" was dedicated to IPM CRSP accomplishments (No. 16, May 2002). In addition, 500 CDs were published with the experiences in Ecuador of farmer field schools and IPM.

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

Ms. S. Garces began graduate studies in entomology at the Ohio State University in January 2002.

Ms. C. Baez began graduate studies in Agricultural and Applied Economics at Virginia Tech in August 2002.

P. Gallegos participated in a three-day seminar-workshop, with technicians and farmers from Perú, Colombia and experts from CIP-Lima.

Danilo Vera C. is doing his MSc studies in Vicosa University, Brazil, financed by PROMSA resources.

Jose Cedeño and Randy Rivera participated in a course about "clean technologies for plantain" in the Dominican Republic.

In March 2002, with the aid of María Crizón of INIAP, Colette Harris gave a training workshop in Carchi for the scientists of INIAP on gender power relations.

In March 2002 Colette Harris gave a gender and community-participative training methodology workshop to INIAP Pichilingue scientists and local school teachers in El Carmen and carried out a series of workshops at INIAP-Pichilngue on the above subjects as well as data collection and analysis.

María Crizón received training from Colette Harris in the participative approach and the latter also aided in the preparation of the three volunteers from San Pedro as well as in a number of the training sessions with the youth and women's groups.

In early May, IPM CRSP scientists from the coastal region of Ecuador – Carmen Suarez and José Cedeño – traveled to Carchi to study the methodology with a view to possible replication on the coast.

Luis Escudero of INIAP was trained in Lima-Perú during November of 2001, on evaluation of IPM impacts.

During June of 2002, Víctor Barrera of INIAP had the opportunity to interchange experiences in Brasilia, Brasil with technicians from other countries on methodologies of participatory training.

Luis Escudero, Jovanny Suquillo, Víctor Barrera, María Crizón, Richard Sandoval and José Romo are participating as Facilitators of the Course of Training to Trainers in IPM, aimed at students of the final grade of the Agronomy Schools of the Technical University of the North and the Catholic University of Ibarra.

Between May and September of 2002, Luis Escudero, Víctor Barrera, José Romo, Rosa Chulde, Richard Sandoval, Jovanny Suquillo and María Crizón trained 50 children, 30 housewives, 40 farmers, 30 agrichemical dealers and 30 high school students in the

principles of IPM and the safe use of pesticides on potato.

Angel Rea participated in the course on Training of Trainers, integrated management of crops and the methodology of Field Schools for Farmers, and also in a course on the methodology of the Local Agricultural Research Committees (LARCs), organized by the IPM CRSP and FAO in the provinces of Carchi and Chimborazo.

Networking

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

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

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

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

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

Several potato activities involved interaction with similar projects administered by the Catholic University of Quito, and with the Ecuadorian Service of Plant Protection (SESA) and with support from the International Potato Center (CIP), based in Lima.

CRSP results were presented at the XX Congress of the Latin American Potato Association, held in Quito from 4-7 June 2002 in Quito, Ecuador.

A short course on entomopathogens was given to MSc students of Biological Control of the Polytechnic School of the Army, (PSA).

In July 2002, Pedro Oyarzún, Stephen Sherwood, Manuel Pumisacho, Diego León, Irina Andrade, Arturo Taipe, Julián Pucha and Raúl Jaramillo participated as trainers in the Workshop: "The secrets of the soil life and its management for a more sustainable agriculture," which was held at Santa Catalina Experimental Station. Participants included farmers from Carchi, Chimborazo and Bolívar.

Pedro Oyarzún, Diego de León and Irina Andrade participated in the International Course of Soils Microbiology, from 19 through 23rd of August of 2002.

Fruit research is being coordinated by the IPM CRSP. Results of fruit research were presented to groups of students from the Central University of Ecuador; the

specialization Chemistry-biology of High Schools such as Hipatia Cárdenas and Inmaculada Concepción of Quito; the Polytechnic School of the Army; the Polytechnic School of Chimborazo; the University of Bolívar; and the Technical University of Ambato.

Results relative to control of the larvae of the beetle *Phyllophaga* sp. with biological products *Metarhizium anisoplae* and *Beauveria* sp. in blackberry *Robus glaucus* Benth were presented at XI National Seminar of Plant Protection in Babahoyo, Ecuador.

Results on soil suppression of naranjilla vascular wilt were also presented at a conference of the National symposium of Plant Protection held in Babahoyo-Ecuador.

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

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

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

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

In April 2002, the third field day was held in Carchi to demonstrate the Farmer Field School advances. Three hundred visitors, both national and international, participated and 30% of them were women. In December 2001, and June and July of 2002, field days were held in Bolívar. Five hundred people attended and 40% of them were women.

The first Course of Training to Trainers in IPM implementation and FSs methodology was held in the province of Imbabura beginning in April, 2002. This course included 51 students (45% women) of the final grade of the Agronomy Schools of the Technical University of the North and the Catholic University of Ibarra.

ASIA REGION

South Asia Site in Bangladesh

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

Description of the Collaborative Program

IPM activities at the Bangladesh site were concentrated in four program areas during Year 9, which was Year 4 for Bangladesh. The first of these areas was vegetable crop pest monitoring; the second was multidisciplinary pest management experiments; the third was laboratory, greenhouse and microplot experiments for biological control; and the fourth was socioeconomic analyses. The work was conducted as a collaborative effort among scientists at the Bangladesh Agricultural Research 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, Ohio State University, Purdue University, and Virginia Tech. ANM Rezaul Karim served as Site Coordinator and Edwin G. Rajotte as Site Chair.

The Year 9 workplan focused on crops, pests, and constraints identified in the participatory appraisal process and in the previous year's crop pest monitoring. Pest management experiments and socioeconomic analyses were refined using the knowledge gained in the past three years. Planning and collaborative research work took place through: a) discussions among host country and US/International scientists at planning meetings in Bangladesh and b) preparation of joint host-country/US/international scientist two-page proposals. Planning for year 10 also involved discussion of the plans jointly with scientists working in the Philippine site during the annual planning workshop at Virginia Tech in May 2002.

Field research is conducted in farmers' fields in Kashimpur and Sripur of Gazipur district, and in Jessore, Comilla and Rangpur districts, with BARI/BRRI scientists visiting experiments at regular basis. Some research is also conducted on-station, especially varietal screening for insect, disease, and nematode resistance in eggplant, tomato, okra and pumpkin. Training takes place primarily at U.S. universities and UPLB. CARE-Bangladesh participated in the planning but not the research and has expressed interest in increased involvement in disseminating the results.

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

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

IPM Constraints Addressed

The key constraints addressed in Bangladesh in Year 9 were the need for IPM solutions to

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

Selected Examples of Research Progress and Results

A detailed description of research progress and results is provided in the individual institution activity reports. The following is a brief summary of research progress and results:

Monitoring of pests in vegetables (eggplant, tomato, cabbage, cauliflower, okra, country bean, yard-long bean, and various cucurbits) identified the most serious insects, diseases, and weeds in Chittagong, Bogra and Rangpur districts. Fruit and shoot borer was a common and serious pest in eggplant. Diamond-back moth and *Spodoptera* caterpillar were abundant and highly damaging in cabbage and cauliflower. Lady's finger had high infestation of green leafhopper. All cucurbit crops (sweet gourd, cucumber, bitter gourd, ribbed gourd and teasel gourd) had high damage from fruit fly. Ash gourd was severely attacked by red pumpkin beetle and aphids. Fruit borer and white fly were common in tomato. Pod borer and aphid were abundant in country- and yard-long beans. Among the diseases, bacterial wilt and root-knot nematode were widespread in eggplant and tomato. Foot and root rot, and little-leaf virus were common in eggplant. Yellow leaf mosaic virus and fruit rot were common in tomato. Cabbage and cauliflower had high incidence of leaf spot. Black mold, yellow leaf mosaic virus and root-knot nematode were severe problems in okra. Virus and root-knot nematode in country bean and leaf spot in yard-long bean were abundant. Farmers applied high doses of insecticides irrespective of the pest infestations. Weeds causing significant damage to various vegetable crops were *Cynodon dactylon, Cyperus rotundus, Commelina diffusa, Lindernia rotundifolia, Garangea maderspatana, Mollugo pentaphylla* and *Alternamthera sessilis*. Fortnightly hand weeding was the common farmer practice, which greatly increased the cultivation cost. A rational weeding schedule can reduce the weeding cost.

Evaluation of selected eggplant varieties produced highly promising results against different pests this year. Both with natural and artificial infestation conditions, 11 varieties showed consistent resistant reactions against fruit and shoot borer (FSB) at vegetative and fruiting stages. FSB larvae feeding on resistant varieties suffered mortality and surviving ones had much lower body weight. They also showed resistant reactions to jassids (green leafhopper), whitefly and aphids. Against bacterial wilt (BW), four eggplant varieties showed resistance, one showing moderate resistance to root-knot nematode (RKN). Seven eggplant varieties showed moderate resistance to RKN, and one of these was also resistant to FSB. Among the selected varieties, several are now found to have multiple resistance (insects, BW and RKN).

Grafting of eggplants or tomatoes was highly successful in respect to its compatibility, grafting success, BW disease control, yields and economic returns. In farmer fields of pilot production of grafted eggplants in Jessore (2 locations) and Sripur (Gazipur), only 7-10% of the grafted eggplants died from other

diseases rather than BW, as compared to 27-31% in fields of farmer practice. Harvest period of the grafted plants was about one month longer, producing 230% more fruits per plant and 256% higher yields than the non-grafted ones. As a result, farmers' net income increased by 286-398% from growing grafted eggplants. Similarly, grafting of tomato on eggplant rootstock was highly compatible with 95% grafting success. Mortality of tomato grafts from BW disease averaged only 1.2% as against 30% of the non-grafted ones. On the average, grafted tomato plants bore 175% more fruits and gave 145% more yield, bringing about 140% increased income.

Hybrid vigor of 25 eggplant hybrids involving 12 parents was evaluated for four agronomic characters in a replicated field test. Highest fruit yield was obtained from four hybrids: Kazla x BL-081 (1143g), followed by BL-114 x BL-083 (895g), BL-083 x SLS-2 (892g), BLS-5 x Uttara (891g), and BL-099 x BLS-4 (851g). These hybrids also showed the highest percent of heterosis over the mid parents and better parents among all the hybrids. They have been selected for further tests because of their higher yields, and better fruit size and color.

Fifty cultivars of pumpkin (sweet gourd) were evaluated under field conditions with artificial inoculation of watermelon mosaic 2 poty virus (WM2V) and plants of 39 germplasms were preliminarily selected as having moderate to high resistance. Among the selected ones, 13 were highly resistant (0% infection), 18 resistant (5-25% infection), and eight moderately resistant (25-50% infection). Also, nine major agronomic characters were characterized. The entries will be further tested for final selection.

The IPM practice in cabbage of removing leaf-eating caterpillars by hand picking and by applying biocides was highly effective in cases where infestation levels were high (32-65% damage), but not at low infestation levels (4-5% damage). In on-farm trials at Comilla where infestation of leaf-eating caterpillars was high, farmer plots receiving 9-11 insecticide applications suffered three times heavier damage (31-36%) than the IPM plots (9-11%) managed through the removal of caterpillars four times by hand picking and one to two applications of biocides. As a result, cabbage yields in IPM plots were 16-23% higher than those of the farmer practice, fetching 25-34% more profits.

Cabbage pest control by erecting net barriers along the sides and on the top proved economically unprofitable. Pest infestation was very low – only 1.5% in plots without net barrier and none in the uncovered plots. As a result, the yield differences were not cost effective.

In Bangladesh, okra is cultivated in the summer season, and cabbage and tomato in the winter season. On-station trials to grow these crops in the off-season (okra in the winter and cabbage and tomato in the summer) by protecting them from biotic (insects and diseases) and abiotic (temperature and rains) stresses showed the possibility of growing them in small plots or home gardens, but the cultivation was not cost effective. The crops were grown under "polytunnels" – one set having a polythene top and a net barrier along the side, the other with only a polythene top. Plots without any protection served as the control. Okra grown under both kinds of tunnels during November-March (winter season) had better plant establishment and growth, and produced 1.2-2 times higher yield. In the off-season cabbage production trial during May-August (summer and rainy), plants suffered high damage from leaf-eating caterpillars and rotting diseases caused by *Fusarium* fungus

and *Erwinia* bacterium; 38-85% of the plants protected under polytunnel were damaged, while none survived when grown in the open without protection. In spite of the damage, the surviving ones produced good cabbage heads, each weighing about half a kilogram. Production of off-season tomato (August-November) is presently going on.

Cucurbit fruit fly management in a bitter gourd crop by using mashed sweet gourd (MSG) bait trap, cuelure pheromone trap, and MSG+cuelure trap showed that cuelure bait trap and MSG+cuelure bait trap attracted the highest number of fruit flies. However, all the fields having bait traps had significantly lower fruit fly infestation producing higher yields. Among the bait traps, MSG+cuelure trap gave the best result.

Year-round mass trapping with MSG and cuelure traps showed that cucurbit fruit flies were prevalent throughout the year in the field, irrespective of the presence of the cucurbit crops. The incidence pattern was seasonal, lower during the winter season and higher during the summer and rainy seasons. In the absence of cucurbit crops, MSG traps failed to capture any fruit fly, whereas cuelure traps captured the fruit flies irrespective of the presence of cucurbit crops. This indicates that cuelure pheromone can attract the flies from long distances. Comparison of continuous trapping for three years from 2000 to 2002 shows a decreasing trend in fruit fly populations.

Weeding operations at critical stages of the crop growth are important for achieving effective weed control, better crop growth and satisfactory yields. On-farm trials with tomato showed that two hand weedings at 21 and 35 days after transplanting (vegetative and flowering stages, respectively) were sufficient to control the weeds effectively for achieving yields better than or comparable to fields receiving three to four weedings practiced by the farmers, bringing about 10% more economic returns. Farmers were able to save weeding costs by 20-45% by adopting this practice. Similar results were also obtained in previous years in on-farm trials of weed management in eggplant and okra crops.

Organic soil amendments often tend to induce weed proliferation in vegetable crop fields. On-farm trials on integrated management of weeds and soil-borne diseases through soil amendment treatments by using poultry refuse and mustard oil-cake in okra fields, however, showed no significant proliferation of weeds for imposing soil amendments. On the other hand, soil amendment treatments reduced plant mortalities and gave good establishment of the crop. Like other weed management trials, okra plots receiving two hand weedings at 20 and 40 days after seeding effectively controlled the weeds and produced higher or similar yields as that of the farmer practice receiving four hand weedings. On average, two hand weedings saved about 13% weeding cost and achieved higher economic returns.

On-farm trials of soil amendment treatments, such as incorporation of poultry refuse, mustard oil-cake, neem oil-cake and saw-dust in tomato seedbed nurseries, produced healthy seedlings, reduced seedling mortalities by 18-43%, controlled root-knot nematode infestation and fetched about 20% higher monetary benefit to the farmers. Similarly, adoption of the soil amendment treatments in the main tomato planting fields reduced the infections of bacterial wilt by 30-67%, virus by 40-60%, and root-knot nematode by 23-49%. Because of better crop establishment and reduced plant mortalities from disease attack, soil amended plots produced, on the average, 17% higher yields, bringing about 20% higher income. Similar results were also obtained in the cucumber crop.

Trathala flavoorbitalis, a larval and pupal parasitoid was found to be highly effective for controlling eggplant FSB. The parasitoid was more aggressive to first instar FSB larvae than to second or third instar larvae. In the presence of the parasitoid, FSB infestation by first instar larvae was only 9%, as compared to 33-40% infestation by second and third instar larvae. In micro-plot tests with artificial release of FSB, plant infestation by FSB decreased by 70% in the presence of the parasitoid. The parasitoid is dependent on the density of its host; the higher the FSB density was, the higher the parasitoid population. Field tests further showed that the parasitoid population increased about 10 times within a year when insecticide applications were avoided in the eggplant fields. As a result, parasitism rates of FSB increased three fold. In laboratory studies, the parasitoid completed its development from egg laying to adult emergence in about 16 days, and 98% of the parasitoids were female, indicating that it is a "deuterototokous" type of parasitoid that produces uniparental adults. Because this type of parasitoid produces a very high number of females, augmentation and conservation through avoiding pesticide applications in eggplant fields will increase its population very rapidly to successfully control FSB.

Technology diffusion studies conducted in farmer fields in two districts for disease management in cabbage and eggplant by using poultry refuse and mustard oil-cake as soil amendment practices, and fruit fly control in bitter gourd and sweet gourd in three districts by using mashed sweet gourd (MSG) bait trap and pheromone cuelure bait trap showed highly promising results. The soil amendment treatments in cabbage and eggplant crops of different farmers reduced plant mortalities by 29-87%, increased yields by 28-106%, and fetched 1.7 to 6 times the economic benefit on a full cost basis as compared to 1.1 to 3.4 times of the traditional practice followed by the farmers. Demonstration of fruit fly control by using the MSG bait trap and pheromone cuelure trap in bitter gourd and sweet gourd fields showed that fields with bait traps had 64-91% lower fruit fly infestations, producing 16-49% higher yields in bitter gourd and 124-245% increased yields in sweet gourd. As a result, farmers received high economic returns.

Mutuality of Benefits of the Research

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

Institution Building

Equipment, vehicles, and other support

Funds were provided for vehicle repair and maintenance, and rental to facilitate transport to and from research sites. Expenses for greenhouse and laboratory renovations, and the purchase of computers, copier and various supplies were provided.

Research training

One Bangladeshi student, Nazrul Islam, is continuing his Ph. D. degree program in weed science at UPLB in the Philippines. One Bangladeshi student, F. Zaman, is continuing his M. S. degree program at Penn State in Entomology. One Bangladeshi student, Ms. Nahar, is undergoing extensive training at

Ohio State in support of her Ph. D. degree at the BSMR Agricultural University in Bangladesh. One Bangladeshi scientist, Anwar Karim, completed a study tour and training on weed science at UPLB in the Philippines. One Bangladeshi scientist, Dr. A. Rashid, completed a two-week training-cum-workshop at Penn State on Techniques on Molecular Biology. One Bangladeshi scientist, Dr. Ismail Hossain, completed a two-week training on socio-economic data processing at Virginia Tech and Purdue University. He also participated in the IPM CRSP annual workshop and planning meeting in May at Virginia Tech.

Scientist travel

S. K. De Datta traveled to Bangladesh in November 2001, to review research progress and appoint research assistants. G. Norton, E. Rajotte, G. Luther, S. Miller, C. Sachs, G. Shively, and A. Baltazar traveled to Bangladesh in January 2002, to review research results and help plan additional research. R. Karim traveled to Virginia Tech to participate in the IPM CRSP annual workshop and planning meeting and to discuss administrative issues.

Human resource development

A human resource development plan for the next two years was revised and includes both short-term and degree training.

Networking Activities

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

Research Accomplishments

Research progress and key results for the past year are summarized above. Among those listed, the success with the eggplant and tomato grafting program against bacterial wilt, soil amendment practices to control soil-borne diseases in vegetables, and the use of bait traps to reduce fruit fly in gourds are particularly significant, as were the results of IPM practice for cabbage pest control, biological control of eggplant fruit and shoot borer, and cost effective weed management practice in vegetable crops. In addition, during the visit of the overseas scientists to Jessore, the results of the IPM CRSP research were highlighted during a half-day meeting with about 100 farmers and members of the local “agricultural clubs,” including local extensionists of government and non-government extension organizations and school teachers. Also, a one-day farmer training on various vegetable IPM practices, including practical training on eggplant graft preparation, was conducted at Jessore. Twenty-five farmers, including three women and three nurserymen, participated in the training program.

Southeast Asia Site in the Philippines

Sally Miller, Site Chair, Ohio State University; Aurora M. Baltazar, Site Coordinator, PhilRice

Program Description

IPM activities in the Philippines site were concentrated in four program areas during Year 9:

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

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

The IPM CRSP Philippines site was successful in Year 7 in obtaining approval for P.L. 480 funds. The five-year, $1.3 million grant entitled "Enhancing the Implementation of IPM to Improve Farmer Competitiveness, Minimize Environmental Risks and Insure Food Security and Safety," was scheduled to begin in January 2001. However, due to fiscal problems in the Philippines government, the allocation of funds has been delayed until January 2003. The total funding level may also be decreased, in which case the following original objectives will be modified accordingly: 1) Explore and implement IPM technologies and generate new technologies for high-value vegetable crops for reduced pesticide misuse, increased farm product marketability, and farm profitability; 2) Develop transgenic crops for improved vegetable production; 3) Assess economic aspects of improved IPM technologies in rice-vegetable production among small farm units; and 4) Develop training materials and implement season-long vegetable collaborative IPM programs. Expansion of IPM CRSP activities into additional provinces with rice-vegetable cropping systems is an integral component of Objective 1. Initial expansion activities and development of training materials and programs (Objective 4), have already started.

The Year 9 workplan was focused on crops, pests and constraints identified in the participatory appraisal process, a structured baseline survey and crop monitoring in years two through four. Planning and collaborative research efforts for the year took place through:

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

As a part of the IPM CRSP expansion into additional rice-vegetable cropping areas in the Philippines, a participatory appraisal process was completed in the provinces of Ilocos Norte, Nueva Viscaya and Pangasinan. The appraisals were carried out by IPM CRSP Philippines scientists and collaborating researchers attached to PhilRice and local universities.

IPM Constraints Studied

Key constraints to IPM in the Philippines that were addresses during Year 9 were:

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

Specific major pests being addressed in the IPM program were the root knot nematode (*Meloidogyne graminicola*), bulb rot (*Fusarium* spp.), pink root (*Phoma terrestris*), anthracnose (*Colletotrichum* sp.), cutworms and armyworm (*Spodoptera* spp.) and various weeds, particularly *Cyperus rotundus* and *Trianthema portulacastrum* in onions. In eggplant, fruit and shoot borers (*Leucinodes orbinalis*), leafhoppers (*Amrasca biguttula*) and bacterial wilt (*Ralstonia solanacearum*) were studied. Research on pathogens causing anthracnose (*Colletotrichum* spp.) and bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria*) of pepper was also conducted.

Selected 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.

- Isolates in several species of the antagonistic fungus *Trichoderma* have been shown to reduce the incidence and severity of soilborne diseases. Efforts in Year 9 were focused on methods of delivery of *Trichoderma* isolates identified by previous IPM CRSP studies as effective biocontrol agents. *Trichoderma viride* and *Trichoderma* sp. (T5-onion isolate) prevented or reduced damping-off and pink root infection caused by *Sclerotium rolfsii*, *Fusarium* spp. and *Phoma terrestris*. *Trichoderma* sp. (T5-onion isolate) applied in powder form as a seed coating followed by a drench application reduced damping-off incidence of onion and suppressed disease development caused by *S. cepivorum*.

- Traps baited with sex pheromones of onion cutworm (*Spodoptera litura*) and armyworm (*S. exigua*) were evaluated as a monitoring tool to time application of insecticide applications in onions by using peaks in trap catches as population indicators. Two population peaks were observed for each species; the second peak overlapped between the two species. After the peak in trap catches, three applications of insecticides were as effective as weekly applications. Use of sex pheromone traps to determine time of application of insecticide can reduce the number of applications from 16-20 (farmer's practice) to one to three in a cropping season.

- Mechanical or chemical stale seedbed techniques applied once or twice in a one-year rotation cycle combined with rice hull burning reduced tuber and shoot populations of purple nutsedge and decreased handweeding times. These results are similar with data obtained from studies combining stale-seedbed treatments with rice straw mulching, a traditional farmers' practice.

- Postplant applications can increase efficacy and selectivity of the herbicide glyphosate for control of purple nutsedge in emerged onion plants, and reduce handweeding and herbicide application costs.

- Application of insecticide had no effect on population densities of the onion leaf miner *Liriomyza trifolii* adults and larvae, or on the percentage of damaged onion leaves. These insecticides were also detrimental to naturally occurring larval parasitoids and predators of *L. trifolii*. Since early season (25 to 30 days after transplanting), defoliation did not reduce bulb size and weight, so onion apparently can compensate from early season damage. Thus, the farmer's practice of spraying insecticides in the seedbed and in the field up to 25 to 30 days after transplanting may not be necessary.

- Bacterial wilt is a devastating disease of eggplant in tropical and subtropical regions throughout the world. Most commercial varieties are moderately or highly susceptible to bacterial wilt. Grafting of commercial eggplant varieties onto bacterial wilt-resistant rootstocks reduced the incidence of bacterial wilt when disease pressure was moderate to high. Yield was not affected by the grafting process.

- The use of combined resistance or tolerance to insect pests in eggplant varieties is a feasible alternative to insecticide application for the management of both *Amrasca biguttula* (leafhopper) and *Leucinodes orbonalis* (fruit and shoot borer). During Year 9, the level of resistance of 16 breeding lines and commercial varieties to these pests was determined. Several lines were identified as potential parental lines for crosses.

- Anthracnose, caused by *Colletotrichum gloeosporioides*, is a relatively new disease problem in onions in the Philippines. It was first identified in Central Luzon after a "La Niña" weather pattern in 2000. Of 14 introduced and local onion varieties evaluated for resistance to this disease, only the native cultivar "Tanduyong" (shallot) was highly resistant. The rest were all very susceptible. However, in a separate trial, "Tanduyong" proved to be among the most susceptible to pink root (caused by *Phoma terrestris*), another serious pathogen of onions. Information on relative resistance of onion cultivars to prevalent diseases will be useful to farmers when other disease management tactics must be considered.

- A relatively unexplored option in IPM is biological control of weeds. In initial pot experiments carried out in Year 9, 15-20 larvae of the insect *Spoladea recurvalis* effectively reduced the leaf area of the weed *Trianthema portulcastrum* by 31-40% within 24 hours. Within 14 days after release of larvae, 80 to 90% of plants were consumed.

- Results of a participatory appraisal conducted in three provinces in north Luzon (Ilocos Norte, Pangasinan, and

Nueva Vizcaya) demonstrated that most farmers are dependent on pesticide spraying to control insect pests, weeds and diseases. The prevailing market price of vegetables and the incidence of pesticide use are directly proportional. Men and women have similar points of view on the use of pesticides, both believing that the use of pesticides is necessary in growing vegetables. While some farmers have received training in rice IPM, vegetable IPM training has been minimal.

- Technology transfer activities carried out in Year 9 reached farmers, trainers, agriculture extension workers and scientists. Activities included 1) carrying out vegetable IPM training courses; 2) preparing an IPM training manual, technical bulletins and a field guide; 3) carrying out techno-demo plots in village level integration studies; 4) development of a 4- and 8-week training curricula designed for training of trainers on IPM in rice-vegetable systems; and 5) holding field days, workshops, and informational meetings.

Mutuality of Benefits of the Research

Most of the pest problems addressed in the Philippines site activities are widespread throughout Asia and also occur in other parts of the world. Strategies developed to manage these pests economically and sustainably can thus be applied to other countries. IPM methods developed for managing pests of onion and eggplant are particular examples. We are continuing to cooperate with IPM CRSP Bangladesh and AVRDC through the GDZ-funded Periurban Project in the development of eggplant grafting technologies to manage bacterial wilt disease. Economic and social impact analyses have shown that strategies such as the use of stale seedbed technology are socially acceptable and 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 was allocated to PhilRice and cooperating institutions in the Philippines. Technology transfer and IPM CRSP expansion studies were primarily funded by PhilRice as part of its current mission to include vegetable IPM as a component of rice production systems.

Human Resource Development

Several students are currently being supported by the project in graduate programs in a collaborating host country university (UPLB) or U.S. institutions. Edwin Martin is pursuing an M.S. degree in weed science at UPLB. Jean Recta is pursuing a Ph.D. in statistics, and Irene Tanzo is pursuing a Ph.D. degree in rural sociology at Penn State. Two IPM CRSP scientists completed their studies and obtained their respective degrees: C.B. Mamaril (M.S., Economics, Virginia Tech) and Evelyn Gergon (partial scholarship, Ph D., University of the Philippines Los Banos).

Networking Activities

Networking is accomplished through institutional collaboration between PhilRice, UPLB, VISCA and other agricultural colleges in the Philippines. PhilRice is part of the

Department of Agriculture (DA) and its national IPM program coordinates with IPM CRSP. Regional networking was also accomplished by attendance and presentation of papers by IPM CRSP scientists at regional meetings in Asia. Participation during Year 9 includes:

S.K. De Datta, S. A. Miller, G.W. Norton, E.G. Rajotte, B. Hedlund, L.L. Black traveled to the Philippines in September 2001 and January 2002 and C. Harris in September 2002 to work with Philippine co-PIs on review of research results, research plans, and visit research sites.

L.S. Sebastian and A.M. Baltazar traveled to Virginia Tech in Blacksburg, Virginia, USA to participate in the IPM CRSP Technical Committee and Planning Meeting in May 2002 and present posters on IPM CRSP research results at the IPM CRSP Symposium.

A poster authored by Alberto, R.T., M.S.V. Duca, S.E. Santiago, N.L. Opina, L.E. Padua and S.A. Miller entitled "Management of soil-borne diseases in rice-vegetable systems," was presented at the 33rd Pest Management Council of the Philippines Conference, May 8-10, 2002 in Davao City, Philippines.

Technology Transfer

Technology transfer activities were extensive during Year 9. These activities were carried out in cooperation with the Training Division of PhilRice, which organized the meetings and prepared the training materials for season-long training programs for Provincial and Municipal Agricultural Officers, representatives from Local Government Units and farmer leaders. IPM CRSP scientists were active participants in these training programs; titles of specific presentations are included in project reports. Specific programs and materials include:

Field Day on March 4, 2002 in Lomboy, Talavera, Nueva Ecija. Attended by Municipal Agricultural Officers, Agricultural Technicians, and farmers from the municipalities of Talavera, Sto. Domingo, and Guimba.

Field Day on March 11, 2002 in Palestina, San Jose City. Attended by Local Govt. Officials, Agricultural technicians, village officials and farmers from Palestina.

Field Day on March 13, 2002 in Kaingin, Bongabon, Nueva Ecija. Attended by Agricultural technicians, officers and members of NOGROCOMA (Onion Growers Cooperative) and other onion farmers in the site of the study.

Meeting with NOGROCOMA (onion growers cooperative) officers and members on August 22, 2002 at Bongabon, Nueva Ecija. Results of field studies on the management of insect pests of onion during the 2002 season were presented and discussed.

Seminar on "Sex pheromones in insect pest management: the case of cutworm and armyworm in onion" presented at PhilRice, Muñoz, Nueva Ecija, September 27, 2002 as part of the PhilRice Anniversary celebration.

R.B. Malasa and S.M. Roguel presented a poster entitled "Social impact assessment of rice hull burning and stale-seedbed techniques," at the IPM CRSP Technical Committee Meeting and Symposium. Virginia Tech, Blacksburg, VA. May 2002.

R.B. Malasa and S.M. Roguel. Social impact assessment of IPM CRSP technologies. Annual conference of the Crop Science

Society of the Philippines. Tagbilaran, Bohol. April 22-27, 2002.

Baltazar, A.M. 2002. IPM in Rice and Rice Cropping Systems: Experiences and Lessons Learned in Philippine Agriculture. Invited paper presented at the Eighth D.L. Umali Memorial Lecture Series. Sponsored by the National Academy of Science and Technology and the D.L. Umali Foundation Inc. Held at the SEARCA Auditorium, U.P. Los Banos campus, College, Laguna, Philippines. July 2002.

Presentations in Local and International Meetings

Arida, G. S., B.S. Punzal, C.C. Ravina Jr., E.G. Rajotte, and N.S. Talekar. 2002. Insecticide application against *Spodoptera litura* (F.) and *S. exigua* Hubner based on trends in sex pheromone trap catches. Poster presented at the 15th National Rice R&D Meeting. April 10-12, PhilRice, Science City of Munoz. Philippines; 33rd Annual Meeting of the Pest Management Council of the Philippines. March 8-10, Davao City, Philippines; and the IPM- CRSP Technical Committee Meeting. Virginia Tech and State University, May 13-17, 2002.

Ravina, C.C., G.S. Arida, B.S. Punzal, E.G. Rajotte, and N.S. Talekar. 2002. Response of the onion plant to simulated damage caused by onion defoliators. Poster presented at the IPM CRSP Technical Committee Meeting. Virginia Tech, Blacksburg, VA May 13-17, 2002.

Alberto, R.T., M.S.V. Duca, S.E. Santiago, N.L. Opina, L.E. Padua and S.A. Miller. 2002. Management of soil-borne diseases in rice-vegetable systems. Poster presented at the 33rd Pest Management Council of the Philippines Conference, May 8-10, 2002 Davao City, Philippines.

Caasi-Lit, M.T., N.L. Opina, R.G. Maghirang, E.G.Rajotte, M.A.A. Capricho, R.V. Lapiz and R.P. Urriza. 2002. Identification of eggplant varieties resistant to leafhopper, shoot/fruit borer and bacterial wilt. Poster paper presented at the Pest Management Council of the Philippines 33rd Annual Conference. Davao City. May 7-10, 2002.

Caasi-Lit, M.T., M.A.A. Capricho, R.V. Lapiz and R.P. Urriza. 2002. Resistance of native varieties and wild relatives of eggplant (*Solanum melongena* L.) against the leafhopper, *Amrasca biguttula* Ishida and eggplant fruit/shoot borer, *Leucinodes orbonalis* Guenee. Poster paper presented at the Annual Scientific Meeting of the National Academy of Science and Technology. Manila Hotel, Manila, Philippines. 11-12 July 2002.

CARIBBEAN REGION

Caribbean Site in Jamaica

Sue Tolin, Site Chair, Virginia Tech; Dionne Clarke-Harris, Site Coordinator, CARDI

Description of the Collaborative Program

The activities of the Caribbean site for 2001-2002 (Year 9) were geared towards bringing closure to ongoing developmental activities and emphasizing wider dissemination and the regionalization of the approach and technologies validated over the last nine years. Efforts have also been focused on harnessing the information and results to affect a greater impact on Caribbean agriculture. Hence, there were greater collaboration linkages between the host country and other CARDI Units and Ministries of Agriculture, as well as the Caribbean IPM Network.

The main collaborating Caribbean and US Institutions over this period include the Caribbean Agricultural Research and Development Institute (CARDI), Ministries of Agriculture (St. Kitts and Nevis, Trinidad and Tobago, Barbados and St. Vincent), Rural Agricultural Development Authority (RADA) in Jamaica, Pennsylvania State University (PSU), Virginia Polytechnic Institute and State University (VPI&SU), Ohio State University (OSU) and United States Department of Agriculture Vegetable Laboratory (USDA-VL).

Over the years, the networking and linkages engendered by the IPMCRSP and the level of collaboration and synergies fostered by the IPM CRSP in advancing research and development of IPM and IPM support systems have greatly expanded. Since the inception of IPM CRSP in Jamaica, many supporting and follow-up local projects have been funded by technical assistance grants under IPM CRSP as well as other donor agencies, resulting in a consolidated effort towards the development of sustainable agricultural systems. The reach of the impact of IPM CRSP activities in the Caribbean site not only extends to all major local (within primary site) research and development (R&D) agricultural entities, but to all premier agricultural R&D institutions throughout the region. The regionalization thrust of IPM CRSP is further facilitated by the Caribbean Integrated Pest Management Network (CIPMNET) as achievements of IPM CRSP are disseminated to the 16 member countries via this mechanism.

IPM Constraints Addressed

For vegetable amaranth callaloo, whose cropping system typifies the global problem of heavy reliance on pesticides in leafy vegetable production, the emphasis has been on the rationalization of pesticide use to increase consumer safety and reduce environmental and user hazards. Results from developmental research activities have demonstrated the potential of an action threshold-based spray application regime to significantly reduce insecticide inputs.

Resistant management protocols and the identification of more effective biorational pesticides have also been validated in the callaloo system. Since IPM ideally seeks to minimize pesticide use in production systems firstly with the effective use of non-chemical methods, exclusion as a management option is also being evaluated. These approaches are applicable to other pesticide dependent systems throughout the Caribbean and are being extended to cabbage production systems in the region.

Sweetpotato weevils, sweetpotato leaf beetles, and the WDS (Wireworm-*Diabrotica*-*Systena*) soil insect complex significantly reduce sweetpotato production in Jamaica and the rest of the Caribbean. The incorporation of pest management tactics, such as resistant breeding lines and the use of biorational insecticides into the present IPM technology, will greatly assist IPM procedures for sweetpotato farmers in the Caribbean to produce high quality products that are competitive in international markets. Hence, in addition to the tactics already developed, the development and evaluation of new techniques is essential and to this end, bioassays using germplasm of different sweetpotato entries and new trapping techniques were investigated in Year 9. Dissemination of IPM technology to farmers in major sweetpotato growing areas in the Caribbean is on-going to facilitate the goal of reducing pest damage and improving sweetpotato production such that it is competitive in the global market.

With respect to the broad mite of hot pepper, the IPM constraints that were addressed in Year 9 were: to confirm that increased broad mite incidence on hot peppers was due to excessive pesticide use, to test biorational pesticides on hot peppers and to control broad mite with minimal effects on its predators. The validation of integrated tactics identified to manage the virus complex as well as broad mite and gall midge complex was deferred to February 2003 in Year 10.

Monitoring and surveillance of the gall midge is now viewed as the critical component to addressing the USA's quarantine issues with this hot pepper pest. As such, much emphasis is being placed on the development of an integrated system that covers the field as well as the ports. Survey mechanisms and web-based databases have been established for effective detection and intervention.

Selected Research Accomplishments

This year, extreme weather conditions in the primary host country have greatly hampered the implementation/continuation of a number of field activities, especially those in hot pepper research. The affected activities have been deferred to Year 10. The disruptions were primarily due to unfavorable conditions for plot establishment, devastation of the fields of participating farmers and the diversion of collaborators, especially in the MINAG and RADA to address more pressing and immediate matters in the agricultural sector, which resulted from heavy rains and associated flooding.

Vegetable IPM

- Two strategies developed for management of major pests of the vegetable amaranth callaloo – (a) exclusion and (b) use of biorationals applied on the basis of pest density (1 larva per six leaf sampling unit) – have continued to give improved plant protection against Lepidoptera species and demonstrate the potential to reduce pesticide use in this cropping system by 75-92%.
- A plan of work (POW) that would realize short-term impact was developed in light of the imminent end of this phase of IPM-CRSP. The POW includes two components conducting 1) Participatory Rural Appraisals of cabbage farmers in Barbados, Jamaica, Trinidad and Tobago, and 2) Evaluation of the potential for use of biorational pesticide.

Sweetpotato IPM

- Sixty-eight and 46 sweetpotato entries were evaluated for resistance to soil insect pests in South Carolina and Florida, respectively. Of these, 46 and 41 entries, respectively, had WDS ratings significantly lower than the susceptible

check cultivars "Beauregard" and SC 1149-19, indicating high levels of insect resistance throughout this germplasm base. Significant resistance to white grubs and flea beetles was also observed.

- Sixteen sweetpotato entries were evaluated at Bodles, Jamaica and most (including local entries) were found to be more tolerant to damage by sweetpotato weevils than the susceptible checks "Beauregard" and SC 1149-19. One entry, PI 531116, from the breeding program of the International Institute for Tropical Agriculture in Nigeria, was found to be the most resistant to damage by sweetpotato weevils. Several sweetpotato entries showed resistance to sweetpotato leaf beetle larvae.
- At Bodles, Jamaica, 16 sweetpotato entries were evaluated and most (including local entries) were found to be more tolerant to damage by sweetpotato weevils than the susceptible checks 'Beauregard' and SC 1149-19. The highest mean mass of tubers was obtained from TIS 30-30, PI 531116 (from the breeding program of the International Institute for Tropical Agriculture in Nigeria) and Picadito, while 96-86 and 94-127 produced significantly higher mean numbers of roots.
- Several sweetpotato entries, such as 94-127, PI 531116, White Regal, Sidges, Tinian and TIS 30-30, showed resistance to sweetpotato leaf beetle larvae in Jamaica.
- PI531116, Picadito, Sidges and Fire-on-Land were among those entries with the greatest insect pest resistance. Tinian (a new entry), though not a prolific producer, also showed high resistance to the insect pests and should be included in further trials.
- Promising new insect trapping techniques were developed for spotted and banded cucumber beetles (*Diabrotica* spp.) and were found to be very efficient for monitoring the former.
- An adult bioassay developed for evaluating sweetpotato germplasm for resistance to cucumber beetles indicated that adults fed on several insect-resistant sweetpotato genotypes and had significantly shorter lifespans than those that fed on the susceptible controls.
- Among 10 types of pheromone traps evaluated for monitoring sweetpotato weevils (*Cylas formicarius elegantulus*), a modification of Talekar's trap was most effective; traps constructed from five-gallon pails or milk jugs also captured significant numbers of weevils.
- The regionalization component of the sweetpotato IPM under the project was continued with on-farm transfer of IPM technology for the management of the sweetpotato weevil.

IPM of Broad Mite of Hot Pepper

- The population of broad mites per plant was about 10-fold higher in samples from fields with high insecticide usage, compared with those from fields with little or no pesticide usage (75.5 vs. 7.3 mites per plant).
- Significantly higher broad mite populations occurred during the wet season (67%) than during the dry season (29%).
- Abamectin, diafenthurion and hexathiazox provided the best combination of maximum suppressive effects on broad mite populations and least on its predators, making these chemicals suitable to use in an IPM program for broad mite on hot pepper.

IPM for Gall Midge of Hot Pepper

- Dr Shelby Fleischer, Vegetable Entomologist of the Pennsylvania State University, USA, visited the CARDI Jamaica Unit 18 – 25 March 2002, and

assisted in the implementation of web based Geographic Information System software designed specifically for the management and analysis of data on gall midge affecting hot pepper in Jamaica.

- A delegation of USDA officials visited Jamaica in December 2001 to review the status of the gall midge on hot peppers in Jamaica and examine systems implemented in the field at the ports to manage and monitor the pest. Information was presented on the work done by the multiagency Hot Pepper Task Force in research, monitoring and training.
- Following the visit of the USDA delegates, the USDA's position of mandatory fumigation of all hot peppers from Jamaica was revisited and criteria for conditional fumigation were outlined. The Task Force is now putting in place the machinery to meet these requirements.
    - A monitoring and surveillance system both at the field and port levels was deemed paramount and the registration of farmers qualified for non-fumigation was also an important requirement.
    - Draft modules have been prepared to compile a handbook, which will assist farmers in meeting the requirements for conditional fumigation of their produce.
    - A traceability system, which links the farmer to the produce submitted for export, was developed and implemented on a manual basis. Software to make the database web-based has been developed and should be operational by December 2002.

Technology Transfer

- A regionalization workshop to train researchers from Barbados and Trinidad and Tobago was held in Trinidad in June 2002, in association with the Ministry of Agriculture, Land and Marine Resources Centeno, Trinidad and Tobago. Participants were trained in a stepwise approach towards the development of IPM strategies for pesticide-reliant vegetable systems, which was developed from experiences with vegetable amaranth in Jamaica.
- This approach of web-mapping for pest monitoring in IPM was introduced to other Caribbean scientists at the Trinidad workshop. The workshop dealt with IPM for leafy greens, and the potential of using this approach with lepidopterans monitored with pheromone traps was discussed.
- In February 2002, Extension Officers from the Ministry of Agriculture from the parish of St. Elizabeth participated in a one-day workshop and field day in the identification of the major pests of sweetpotato in Jamaica and their damage to sweetpotato. Strategies used in an IPM program were also outlined. The participants also took part in an exercise to make pheromone traps and to place them in a farmer's sweetpotato field.
- The Department of Agriculture (DOA), St. Kitts, held its open day in April 2002, while the DOA, Nevis, staged theirs in May 2002. On both occasions, CARDI's presentation was "Sweetpotato Production, from Field to Factory." It involved displays of some sweetpotato varieties, information on IPM and displays of processed sweetpotato products, such as chips, fries, etc., which were sampled by the public.
- Workshops focusing on various phases of crop management in hot pepper production were held in Walkers Wood, St. Ann, Jamaica. Four workshops were held on (1) Seedling production, (2) Land preparation, (3) Soil and water management, and (4) IPM. The 14 farmers in the farmers' group of the

Walkers Wood community benefited from demonstrations and hands on training in aspects of these stages of production, which promote sustainability, especially environmental conservation.
- A draft handbook on sustainable agricultural practices in hot pepper production has been produced.
- Training was given to in-country collaborators in identification of broad mites and their predators, and in sample preparation for pesticide residue analyses.

Networking Activities

- A seminar, "*The assessment of effects of pesticides on soil organisms, particularly earthworms*" was presented by Clive Edwards, Entomologist and Environmental Ecologist, Ohio State University, 5 March 2002, CARDI Conference Room, Kingston, Jamaica.
- Shelby Fleischer and Paul Blom of the Pennsylvania State University visited Jamaica in March 2002 to demonstrate the website application developed and adapted for use in the management and analysis of data on gall midge affecting hot pepper in Jamaica.
- D. Clarke-Harris, Entomologist and IPM CRSP Site Coordinator (Caribbean Site) was one of a panel of experts at a regional workshop entitled "*Reduction, Elimination and Management of Pesticides in the Context of the Stockholm Convention on Persistent Organic Pollutants and the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal*," held in Port of Spain, Trinidad, 22-25 April 2002, during which she delivered a paper, "*IPM Related Activities in the Caribbean Region*." This workshop was jointly organized by the United Nations Environment Programme (UNEP) and the Basel Convention Regional Centre for the Caribbean region (CARIRI).
- S. Tolin, D. Clarke-Harris, K.M. Dalip, S. Fleischer, C. Edwards and D.M. Jackson, together with J. Momson and C. Harris, participated in the IPM CRSP Annual Planning Workshop, Blacksburg Virginia, in 15-18 May 2002.
- Dr. D.M. Jackson, attended the International Symposium, "Sweetpotato, Food and Health for the Future," Universidad Nacional Agraria La Molina, Lima, Peru, 26-29 Nov 2001.
- Dr. D.M. Jackson attended the National Sweetpotato Collaborators Meeting, Feb. 2-3, 2002, Kissimmee, Florida.
- Drs. D.M. Jackson and J.R. Bohac served as members of the Sweetpotato Crop Germplasm Committee.
- Dr. D.M. Jackson traveled to Jamaica 17-23 February 2002 to assist in harvest of sweetpotato trial and to plan for future cooperative work.
- Dr. D.M. Jackson met with Aziz Lagnaoui (CIP, Lima, Peru) in Lima to discuss cooperative work with *Beauvaria bassiana*.
- Dr. D.M. Jackson shipped proprietary (Trécé) lures and traps to cooperators in Jamaica.
- Drs. J.R. Bohac and D.M. Jackson shipped USDA-developed, dry fleshed sweetpotato clones to Dr. K.M. Dalip to evaluate their potential in Jamaica.
- Dr. D.M. Jackson presented the seminar "Overview of Pest-Resistance/Sweet-potato Breeding Program" in Jamaica in February 2002.

Regionalization of IPM Technology

Vegetable IPM

D. Clarke-Harris Entomologist, IPM CRSP Site Coordinator (CARDI Jamaica); Shelby Fleischer, Vegetable Entomologist (Penn State University); and Greg Luther,

Entomologist (VPI) were resource persons in a two-day Regionalization Workshop**,** "*Development of IPM in Leafy Vegetables that Currently Experience High-pesticide Input*," which was held 12-13 June 2002, at Ministry of Agriculture, Centeno, Trinidad. The workshop was geared towards researchers and involved participants from Barbados and Trinidad and Tobago and resource persons included scientists from Pennsylvania State University, Virginia Polytechnic Institute and State University, CABI and CARDI.

Sweetpotato IPM

The regionalization component of the sweetpotato IPM under the project was continued after being initiated in Year 6. Varietal trials were carried out in St. Kitts and the results, as those of previous trials, suggest that that local lines of sweetpotato grown by Kittitian farmers performed better than many of the recently introduced lines. They survived better and were more tolerant to stem and root damage by sweetpotato weevils under the dry exposed field conditions in which the plants were grown.

Impacts

Leafy Vegetables

The work on the vegetable amaranth (callaloo) in Jamaica was a classical approach to developing IPM systems for reducing pesticide input in highly pesticide reliant vegetable systems. The research approach used has applicability to crops with similar constraints within the Caribbean.

The decision to tackle the problem of over-reliance on pesticides in cabbage and crucifer production is from all indications a well needed and timely one. The two activities planned to initiate these studies in the region will give valuable information in the short term and will also assist in the identification of critical areas to be addressed and the formulation of proposals to address these needs in the expected renewal phase of the IPM CRSP. The nexus between the activities of the project "*Ecological Crop Management Using Farmer Participatory Approaches*" and the participatory approach of the IPM CRSP will facilitate a close linkage and synergy between the two projects.

Scientists who participated in the regionalization workshop, "*Development of IPM in Leafy Vegetables that Currently Experience High-pesticide Input*," held in Trinidad, 12-13 June 2002, got first hand information on the IPM CRSP research activities carried out in Jamaica, as well as the results and applicability to their respective countries.

Sweetpotato

Sweetpotato is an important traditional crop for many countries in the Caribbean, both as an export product and as a staple of the diet of the local citizenry. Several similarities and differences exist among the islands of the Region. For example, the pest complex is similar in many of the islands, with the sweetpotato weevil being the most important pest, while differences occur in ecological zones as the crop is grown at different altitudes. Improved agronomic/cultural practices, such as moulding and irrigation and fertilizer application, could well improve yield and weevil tolerance of the various lines, leading to the production of more marketable roots.

Under the sweetpotato IPM component, the identification of several sweetpotato varieties that show tolerance to the major pests, and the potential inclusion of botanical insecticides, biorationals, floral-lure and pheromone traps and new insect monitoring techniques, which may be included in an IPM technology, are positive moves towards the ultimate goal of

reducing pest levels on the crop and hence, improving the yield and quality of sweetpotato production in the Region so that they can become competitive in international markets.

Hot Pepper
With the USDA revision of the mandatory fumigation requirement for hot peppers exported to the USA from Jamaica, the Jamaican farmer exporter has the opportunity to maintain a competitive presence in the US marketplace. The traceability system, as well as the Web-GIS field monitoring database will play a significant role in effective monitoring and surveillance.

Maps generated by Web-GIS will provide a graphic snap shot of gall midge distribution and incidence in the sampled growing areas for a given period. Where these are promptly updated, they will indicate areas of gall midge-free or low infestation. This is of particular importance to exporters of fresh fruit to the US, as it will reduce the need for fumigation under a proposed program for conditional fumigation.

The data on broad mite from field surveys and field experiments will provide inputs that enable progress towards multiple-pest IPM in hot peppers.

Support for initiatives in market analysis continued and an assessment of the profitability of the industry in Jamaica was conducted as part of regional survey of countries. Of 20 issues, the highest ranking were: lack of irrigation, weed management, high cost of production, farmers' inability to synchronize production with periods of high market demand, and marketing constraints for processors and exporters.

EASTERN EUROPEAN REGION

Eastern Europe Site in Albania

Douglas G. Pfeiffer, Site Chair, Virginia Tech; Josef Tedeschini, Site Coordinator, Plant Protection Institute, Durrës

Description of the Collaborative Program

IPM research activities on olive production in the Eastern European (Albania) site continued during 2001-2002 and concentrated on three major activities:

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

The work during Year 9 (which was Year 3 for Albania) was conducted based on close cooperation between scientists of the Albanian agricultural research institutes and different US universities. The major Albanian institutions involved are the Plant Protection Institute (PPI) at Durrës, Fruit Tree Research Institute (FTRI) at Vlora and Agricultural University of Tirana (AUT). Partner US institutions are Virginia Tech, Penn State and University of California.

The Year 9 work plan was focused on olive and its pest management problems and constraints identified in the PA. Planning and collaborative research took place through discussions among host country and US scientists at planning meetings in Albania. The research takes into consideration the developing results of the previous year.

Field research was conducted at an experimental station of FTRI and in two

villages. The monitoring activities were done in several places in the Vlora region.

Laboratory analyses were conducted in FTRI, PPI and AUT. The site chair and coordinator have maintained frequent communication and all co-PIs are encouraged to maintain communication with their respective collaborators on individual research activities.

The host country site coordinator frequently oversees the field research activities together with the other specialists involved in particular research topics.

IPM Constraints Studied

The key constraints addressed in Albania in Year 9 were the need to improve the IPM solutions to specific pest problems in olive crops and the need for information on socio-economic factors influencing the adoption of IPM. Specific major pests being addressed during this year in the IPM program are olive fruit fly (*Bactroceroleae*), olive moth (*Prays oleae*), Mediterranean black scale (*Saissetia oleae*) leaf spot disease (*Spilocaea oleaginea*), olive knot (*Pseudomonas savastanoi*), nematodes, some minor pests and several weeds.

Selected Accomplishments

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

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

The main research IPM activities during 2001-2002 were done at the Experimental Station of FTRI (Shamogjin) in the Vlora Region. Field surveys were conducted for the incidence of pests, diseases, nematodes and weeds in olive orchards. Different pheromones were tested for the monitoring of key pests. The olive moth continues to be a serious pest. An integrated pest management system that uses pheromone baited traps to monitor olive moth populations and to time the application of control measures could be implemented.

The olive fruit fly remains the most important olive pest in this region. Olive fruit fly adults are very active from August until October with the maximum of catches occurring in autumn.

Among the most important olive fruit fly parasites were the chalcid ectoparasites *Eupelmus urozonus* and *Eurytoma martellii*. Our understanding of the role of natural enemies of black scale in maintaining this pest below economic threshold level has improved. Parasitism rates by *Scutellista cyanea* (a parasite of black scale) were very high in several places and the activity of entomopathogenic fungi was observed. During the spring season, infestations of *Euphyllura olivina* (Psyllidae) were also common.

Data were collected to estimate actual fruit damage by olive moth and olive fruit fly. A high level of olive moth infestation was observed particularly on cv KMB and Kalinjot. Olive fruit fly infestation starts at the end of July and reaches high levels due to the high humidity during the autumn season. Severe olive infestation is generally associated with significant losses, especially in early ripening olive cultivars. Infestation has been shown to vary with variety.

In the Vlora region, *Aceria oleae* was the most important species among the eriophyid mites living on olive trees. *Ditrymachus athiasella and Tegolophus hasani* were also present. The most susceptible olive variety

was cv Kalinjot, with the highest infestation on leaves, flowers and fruits. Eriophyid mite infestations pose another problem that will be included in our efforts to develop IPM approaches.

Observations made in olive orchards again confirmed that leaf spot and olive knot are the two most important diseases of olive trees in Vlora district. The incidence of olive knot was 2.1 galls / m^2 of canopy and field monitoring showed that the highest levels of leaf spot disease appeared during March-April.

Nematodes were monitored in soil as well as root samples this year. In the soil samples, *Helicotylenchus pseudorobustus, Pratylenchus thornei, Gracilacus* spp., *Paratylenchus projectus, Paratylenchus dianthus, Geocenamus* spp., and larval populations of *Rotylenchulus macrodoratus* were identified, whereas in the root samples, Pratylenchus *thornei* and Rotylenchulus *macrodoratus* females were collected.

To develop an effective weed control strategy, measurements of weed density and identification of dominant species have been conducted in the olive tree area in Shamogjin. In this year's samples, 32 different botanical families of weeds were present. The dominant species among the shrubs were *Dittrichia viscose* (L) W. Greuter and *Rubus ulmifolius* Shott; among the grasses, *Koeleria gracilis* (L.) Pers, *Apera spica-venti* (L.), *Poa annua* (L.), *Bromus textorum* (L.), *Lolium* sp. (L.), *Festuca* sp. (L.) etc.; and among broad leaves most widespread were *Logfia* sp. (Gass), *Trifolium resupinatum* (L.), *Trifolium repens* (L.), *Medicago arabica* (All), *Ononis spinosa* (L.), and *Coronilla scorpiodes* (L.) Koch).

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

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

The olive oil analysis of cv Kalinjoti done at OLITECN S.R.L. laboratory (an accredited lab by IOOC in Greece) indicated that when using our experimentally derived early harvesting dates, it is possible to produce extra virgin olive oil when harvesting early enough to avoid third generation olive fruit fly infestation. Olive oil in the virgin category, produced on October 15 and November 1 had lower values of free acidity as compared with the olive oil produced on November 15.

Organic Methods of Vegetation Management and Olive Insect Control

The efficacy of several application methods against weed and olive pests were evaluated during 2002. The third year experiments demonstrated that the use of several more environmentally sound management methods can be integrated into IPM programs for olive organic agriculture.

In experimental groves of FTRI, the use of mulching straw indicated good suppression of weed competition and conservation of soil moisture over extended durations. In the mulching treatment, good productivity of olive trees compared with other treatments was observed. Mulching treatment should replace herbicide-based weed management in the future. The herbicides diuron and glyphosate have also been effective in controlling weeds in a conventional production system.

To control the key pests of olive crops, alternatives that will provide minor risk to the farmers and the environment are being

developed. In the research project, we evaluated the efficacy of the microbial insecticide *Bacillus thuringiensis* (Bt) applied with conventional high volume air blast sprayer to control olive moth. In the organic production system where Bt was used, the number of natural enemies was higher compared with those in the conventional system where the broad-spectrum insecticide BI 58 (dimethoate) was applied.

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

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

During 2002, three levels of pruning severity (non-pruned, lightly pruned and heavily pruned) continued to be tested. Olive trees in the heavily pruned treatment gave good linear vegetative growth. The canopy volume had a good shape and shoot growth compared with other pruning treatments and non-pruned trees. Also, the fruit production was much higher than the non-pruned and lightly pruned treatment. In addition, water sensitive papers attached to branches demonstrated that spray penetration is much greater in trees with more open canopies and thus the quality of application of plant protection products can be improved.

Another experiment was carried out applying treatments with copper fungicides every month (October-May) to determine the best time of spraying to control leaf spot and olive knot. Results show that the treatments during spring (March, April) and autumn (October) provide the best protection. Leaf spot disease management was significantly improved.

In general, this project will allow greater implementation of a non-chemical tactic and organically acceptable products into olive IPM.

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

The "Attract and Kill" method, an improved form of mass trapping to control olive fruit fly was evaluated in several olive groves during 2002. Results through early October indicated that in isolated olive groves and in areas where olive fruit fly infected late ripening cultivars (cv Kalinjot), this method has the potential to keep the olive fruit fly population and fruit infestation low.

In non-isolated olive groves where the olive fruit fly developed a high population density on early ripening cultivars (cv Frantoi), one trap per tree provided inadequate protection. For that reason, curative treatment with insecticide is needed to keep the fly population and the fruit infestation at a low level. Further research is needed to determine under what conditions supplemental control actions are needed.

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

especially in light of the recent introduction of olive fruit fly into the U.S.

Institution Building

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

Scientists Travel

M. McGiffen traveled during the last week of October 2001 to help set up the vegetation management experiment.

C. Pitts and P. Tobin traveled to Albania from February 25 – March 2, 2002 for a follow-up on the statistical course.

D. Pfeiffer and R. Hedlund traveled to Albania from May 6 – 12, 2002 to help Albanian scientists in setting up different experimental trials and starting the discussion on a possible new project of IPM CRSP-Albania.

Human Resource Development

One graduate student, Lefter Daku, was supported through this year by the Albanian IPM CRSP site in the Department of Agriculture and Applied Economics at Virginia Tech. It is planned to bring a second student to the Department of Entomology next year.

Networking Activities

The IPM CRSP research results were presented in several Workshops organized in the main olive growing regions of Albania.

In the Workshop on the Technology of Olive Oil Production organized by AOA (Alimentary Oil Association) on April 5-8, 2002 at Fier, a presentation was made by one of our specialists ("Effect of Harvesting Time on Olive Fly Infestation and Olive Oil Yields and Quality").

A paper and a videotape describing results of IPM CRSP studies on vegetation management and olive pest management in organic groves were presented at IFOAM's 1st Worldwide Conference on Ecological Olive Grove: Production and Culture, held on May 22-25, at Sierra de Segura, JAEN-Spain.

Participation in an organic inspector training course that took place on May 25-31, 2002, in Durres. In this training, the contribution of our project toward the development of organic agriculture on olive and the new technique of vegetation management and other alternatives to control olive moth and olive fruit fly in organic olive groves were presented. There were about 20 specialists from different Albanian institutions and from the main olive growing regions.

IPM CRSP Annual Meeting from May 15-20, 2002, Blacksburg, Virginia Tech. The results of organic methods of vegetation management and mass trapping experiment were presented with two posters.

In cooperation with the Albanian Extension Service, six meetings were organized (in Saranda, Berat, Fier, Tirana, Elbasan and Vlora districts) with specialists, farmers and olive growers. The technology of appropriate pruning of olive trees was presented and the possibility of improved control timing for leaf spot and olive knot by copper fungicides was explained. These meetings were attended by about 200 people. The results of the above experiments were published in "Pemtaria" a periodical of FTRI Vlora (3 publications per year).

A workshop with inspectors and farm-advisers was held at the Ministry of Agriculture on August 2, 2002. Twenty participants from the main region of olive cultivation attended and improved their knowledge in mass trapping methods. Leaflets on the mass trapping technique were distributed. The possibility of using the "Attract and Kill" method to control olive fruit fly was demonstrated in the main olive cultivated areas in Albania (5000 olive trees).

Technology Transfer

Organization of statistical short course with Penn state University February 25 – March 2, 2002. Twelve specialists from PPI, FTRI and AUT participated.

BOARD OF DIRECTORS

The annual IPM CRSP Board of Directors meeting was held at Virginia Tech on April 3-4, 2002. Attendees were:

Appointed members:
Bobby Moser (Chair; Ohio State University), Hiram Larew (USDA), Tom Mew (International Rice Research Institute), Deanna Behring (Penn State University), Samson Tsou (AVRDC), Richard Robbins (North Carolina A&T University), Sharon Quisenberry, (Montana State University), David Sammons (Purdue University), Zahurul Karim (Bangladesh Agricultural Research Council), Frank Zalom (University of California).

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

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

S.K. De Datta (Principal Investigator, IPM CRSP) gave the Welcome Address and Report to the Board, entitled, "Lessons from the Past and Reflections on the Future" in which he stressed "the ME team has one major goal: the total success of the IPM CRSP as a whole with sufficient programmatic entrepreneurship at each site."

Major decisions made by the Board included:

- The Minutes of the Board of Directors Meeting of 9-10 April 2001 were approved as they stood.
- Program Director Brhane Gebrekidan highlighted major IPM CRSP impacts at each site.
- The Board reviewed the EEP report based on visits to all eight sites. Improvements were noted in sites, which had originally been weak, and it was suggested that those stronger sites become regional models to emulate.
- The EEP report recommended, "that the IPM CRSP be funded for Phase III."
- The Policy and Operating Procedures (POP) Manual has been updated based on several TC and Board recommendations. Additional changes are expected.
- The Administrative Management Review (AMR) Report Recommendations (1-14) were reviewed and the Board suggested that appropriate changes be made to update the POP Manual.
- The Board discussed the process and strategies for Phase III renewal. The SPARE Chair presented the process and focus of SPARE review of the renewal proposal. However, the SPARE Chair noted that a review of all USAID IPM activities appears imminent and may affect the renewal process.
- The Board recommended that the IPM CRSP move forward with the renewal proposal process. The Board Chair summarized ten points that should be considered in the renewal proposal: (1) We cannot have a proposal that is business as usual; (2) Build on our strengths with new directions and new focus areas, such as food safety, global trade issues, poverty reduction, biotech, invasive species, nutrition and health; (3) Do we maintain the same sites? Do we have too many? We have more than many CRSPs; (4) When has a site met its graduation requirements? What are 'mature site' criteria? Build in requirements so we know if IPM CRSP pulled out from a site today, whether it

will still continue. The IPM CRSP needs to have a clear policy regarding mature sites and the continuation of their activities after the CRSP has left; (5) Capacity building; (6) Discussion about the management team approach: it fits with IPM CRSP because it is an integrated approach. Define who is responsible for what, so Site Chairs know; (7) We need an external review team to evaluate the renewal proposal before we submit it; (8) Phase III should include an open competition; (9) Ways of using the web for information dissemination; and (10) Networking and regionalization.

- The Board Chair thanked OIRD for their hospitality and noted that when the RFP goes out it must say it is an open process.

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

TECHNICAL COMMITTEE

The IPM CRSP Technical Committee (TC) held its main annual meeting at Virginia Tech in Blacksburg, Virginia, on May 15 - 18, 2002. Technical Committee members for Year 9 of the IPM CRSP were:

George Norton, TC Chair
Ed Rajotte, Site Chair, Asian Site in Bangladesh
Sally Miller, Site Chair, Asian Site in the Philippines
Mark Erbaugh, Site Chair, East Africa Site in Uganda
Rezaul Karim, Host Country Site Coordinator Representative
Keith M. Moore, Site Chair, West Africa Site in Mali
Sue Tolin, Site Chair, Caribbean Site in Jamaica
Glenn Sullivan, Site Chair, Central American Site in Guatemala
Jeff Alwang, Site Chair, South American Site in Ecuador
Doug Pfeiffer, Site Chair, Eastern European Site in Albania
Michael Irwin, External TC Member
Carolyn Sachs, Gender Specialist
Aziz Lagnaoui, International Agricultural Research Center Representative
S.K. De Datta, Principal Investigator, IPM CRSP
Brhane Gebrekidan, IPM CRSP Program Director
Greg Luther, IPM CRSP Assistant Program Director
Bob Hedlund, IPM CRSP Project Manager, USAID

In addition to the Technical Committee Meeting, a Gender Workshop was held to strengthen inclusion of gender issues in IPM CRSP research activities. A poster session was also held to present site research progress. In addition to TC members, host

country Site Coordinators and many other co-PIs attended the Symposium, poster session, and Year 10 Planning Meetings at Virginia Tech.

In this May 2002 meeting, the IPM CRSP Executive Committee (a subcommittee of the TC) met and made the following decisions:

- Allocations to each site will start with the same numbers as last year.
- The EC recommended that if the IPM CRSP gets new money, the top priority is to allocate $50,000 to Albania, if needed for bridge funds, and the next highest priority is to fund regionalization in the Caribbean site – at least $20,000. Any additional money should be used for regionalization in all sites and allocated on a competitive basis.

The TC approved the following budget distribution across sites for Year 10 of the IPM CRSP:

Site / Activity	***Year 10 budget***
Guatemala	$ 179,000
Philippines	$ 189,000
Jamaica	$ 156,000
Mali	$ 184,000
Uganda	$ 234,000
Bangladesh	$ 244,000
Ecuador	$ 239,000
Albania	0
Global Themes	$ 40,000
Biotech	$ 255,000

Other major decisions made by the TC include the following:

- The TC approved the minutes of the last meeting and conference call review of the biotechnology proposals, including key revisions that should be made in each proposal.
- A committee was established (Lagnaoui, Tolin, Irwin, and Gilbertson) to design an insect transmitted virus plan for the CRSP funded with global funds.
- IPM CRSP Participation in the National IPM Symposium next April was discussed.

The minutes for these meetings are available on request from the IPM CRSP ME.

TRIP REPORTS, YEAR 9

Trip reports from Year 9 of the IPM CRSP totaled as follows:
Albania: 1; Bangladesh: 1; Ecuador: 2; Guatemala: 2; Honduras: 2; India: 1; Jamaica: 2; Mali: 7; Philippines: 2; Uganda: 6. These reports are all posted on the IPM CRSP web site:
http://www.ag.vt.edu/ipmcrsp/

Table 1: Publications, Presentations and Other Products of the IPM CRSP

Cumulative Compilation through May 13, 2002

Category	*General /Other*	*Albania*	*Bangladesh*	*Ecuador*	*Guatemala*	*Jamaica*	*Mali*	*Philippines*	*Uganda*	*Total*
Papers Published in Refereed or Reviewed Publications	0	0	2	4	10	20	6	19	18	79
Books/Book Chapters	0	0	0	0	2	0	0	0	0	2
Theses and Dissertations	0	0	3	9	8	4	3	4	10	41
IPM CRSP Annual Reports and Highlights	12	0	0	0	0	0	0	0	0	12
Extension Publications (large)	0	0	1	1	4	11	3	4	4	28
Proceedings (not refereed or reviewed)	14	0	0	0	67	14	10	42	17	164
IPM CRSP Working Papers	2	2	2	1	4	0	3	7	3	24
World Wide Web Sites and Documents	2	1	0	0	0	3	0	0	0	6
Germplasm Releases	0	0	0	0	0	7	0	0	0	7
Workshops, Courses, Field Schools and Field Days	0	3	1	30	28	20	10	10	23	125
Papers/Seminars Presented	0	6	0	23	71	54	31	44	93	322
Electronic Presentations	0	0	0	0	0	4	0	0	0	4
Posters	1	0	1	0	3	27	3	32	11	78
Fact Sheets (small ext. pubs.)	0	1	0	0	0	4	1	20	6	32
Newsletters	20	0	0	0	0	2	1	2	3	28
Videotapes	0	0	0	1	0	1	6	1	0	9
Magazine and Newspaper Articles	0	0	0	0	1	0	0	2	3	6
Reports	42	21	58	66	177	185	119	154	110	932
Abstracts	0	0	0	0	2	9	3	2	6	22
Bibliographic Databases and Miscellaneous	0	0	0	0	0	0	1	6	0	7
TOTAL	93	34	68	135	377	365	200	249	307	1928