# Integrated Pest Management
## Collaborative Research Support Program
## (IPM CRSP)

**Annual Workplan**
**for Year Ten**
**(September 29, 2002 to September 28, 2003)**

***Final Version – September 2002***

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## IPM CRSP US Institutions

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

## Host Country Institutions

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

## International Centers

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

## Private Sector

The Kroger Company PICO Caito Foods

## NGOs/PVOs

CLADES; GEXPRONT,Guatemala; CARE,Bangladesh

# Table of Contents

# Tenth Year IPM CRSP Annual Workplan

# (September 29, 2002 – September 28, 2003)

This workplan describes the research and other activities to be undertaken during the ninth year of the IPM CRSP, including their timing, scientist time required, expected outputs and impacts, and expected budget allocation. Research objectives and hypotheses are noted and a description of each activity is provided. Workplans were developed by site committees and discussed and approved by the Technical Committee. Activities in the plan are directly related to the five major objectives in the proposal for the second five-year phase of the IPM CRSP.

**Program Objectives from the IPM CRSP Proposal for Its Second Phase**

Objective 1. Identify and describe the technical factors affecting pest management

Objective 2. Identify and describe the social, economic, political, and institutional factors affecting pest management

Objective 3. Work with participating groups to design, test, and evaluate appropriate participatory IPM strategies

Objective 4. Work with participating groups to promote training and information exchange on PIPM

Objective 5. Work with participating groups to foster policy and institutional changes

**The Year Ten Plan in Perspective**

Year ten marks the fifth year of the second five-year phase of the IPM CRSP. The program completed year nine with seven prime sites (The Philippines, Guatemala, Jamaica, Mali, Uganda, Ecuador, and Bangladesh) fully operational, and the Albania site winding down with carry over core funds provided by the USAID mission (funds run through the Global Bureau). A reporting workshop was held in May at Virginia Tech to share results of IPM CRSP research across the whole program, followed by a planning workshop. The Technical Committee met three times during year nine. An IPM CRSP annual report, highlights report, and several newsletters were produced.

The workplan that follows is organized by region and by country site. Brief progress reports for continuing activities are found within the workplan activities described for each site. Progress reports for completed activities are included in the annual report for year 9 and in a special document prepared by the IPM CRSP entitled IPM CRSP Highlights.

Year ten research activities reflect the expanded effort in biotechnology related to IPM that was begun in Year 9. Special attention is devoted to incorporating biotech solutions to pest management problems in several sites as part of IPM CRSP globalization efforts.

**Cross-Cutting Activities in the Tenth Year**

**1. Workshop for Information Sharing Across Sites and for Planning for Year Ten**

A workshop will be planned and implemented that will include all U.S. scientists and at least one host country scientist from every site. A program of scientific papers will be assembled that will address central themes on the IPM CRSP. A poster session will be held for additional presentation of results. A planning workshop will follow as part of the preparation for year eleven. A technical committee meeting will be held immediately before and after the workshop to assess technical progress, critique workplans and discuss technical issues common across sites.

**2. Participation in National IPM Symposium in Indianapolis**

IPM CRSP work will be presented in the international session at the National IPM Symposium in April 2003 and in the IPM impact assessment session. Two IPM CRSP members are co-chairs of sessions at the symposium.

**2. Globalization**

Several globalization activities will be undertaken during year 10. First, the IPM CRSP book is in progress and will be sent to a press during year 10. This book will summarize the participatory approach used on the IPM to globalize IPM programs and solutions. Second, regionalizing of IPM CRSP results will continue in each region both through targeted research activities and IPM training of students who may not be from one of the prime sites. Third, scientific papers will be presented at international meetings and published. Fourth, close collaboration with international agricultural research centers such as AVRDC, CIP, IRRI, and IFPRI are helping the IPM CRSP spread its results into key IPM networks. Fifth, collaboration with international NGOs that are active in IPM outreach is helping to spread research results. Finally, the expanded effort in biotech will address pest problems that are global in nature.

**Information Exchange and Networking**

IPM CRSP newsletters will be produced and available in hard copy and on-line, facilitating contact within the IPM CRSP, other CRSPs, and with outside IPM interests. The IPM CRSP web site with all trip reports, working papers, and other reports will be maintained to make IPM CRSP results globally available to all with internet connections. The Africa IPM Link web site, both in English and in French, will continue to focus on IPM related issues in Africa. An IPM bibliographic search service is available through IPM CRSP collaborating scientists at Penn State.

**Biotechnology Statement**

Virginia Tech and other collaborating institutions each have their own Biotechnology Compliance Committees. They will review any proposed biotechnology component of the program to ensure compliance with all relevant regulations dealing with biotechnology and genetically engineered biological products. We will also network with CGIAR initiatives to introduce pest-resistant varieties in our research sites. Year ten will be a year when the IPM CRSP makes a major step forward in integrating biotechnology research into the IPM program. Biotechnology research activities directed at insect problems in eggplant in Asia, a virus problem on peppers in the Caribbean and Latin America, late blight on potato in Latin America, are just some of the activities planned in this area. Some of the biotech activities are funded through the site budgets and some are funded in special projects that were approved through a special call for proposals.

**Intellectual Property Rights**

An agreement on intellectual property rights will be worked out on a case-by-case basis with collaborating institutions at each site.

**Response to AID Requests for IPM Technical Assistance**

The IPM CRSP will respond to requests from USAID missions for IPM technical assistance (TA) in other countries as specified in the grant. These activities will be cost-shared by the requesting missions. Exact details of this cost sharing will be determined on a case-by-case basis in discussion among the ME, the mission, and USAID's Office of Agriculture. A dedicated fund has been set aside by the IPM CRSP for technical assistance. In year ten, TA funds that were allocated to special projects in the past, but have not been fully spent, will be redirected to the general TA fund to augment the available TA resources. Funds allocated to coffee wilt in Uganda and Gall Midge in Jamaica will continue to be spent for those purposes.

**External Evaluation**

The External Evaluation Panel is scheduled to meet once during the year.

**Technical Committee Meetings**

The technical committee will have at least three meetings during the year, at least one of them face to face.

**Board Meeting**

The board will meet in March 2003

**Degree Training**

In addition to short-term training, graduate students from the host countries or from the United States are assisting in the program and writing theses and dissertations. These students may be graduate students at academic institutions in the host countries or in the United States. A listing of the specific students, and their nationality, discipline, site, degree, and university is provided in Appendix table 1. The majority of these students are from the host countries.

# Tenth Year Workplan for the Asia Site in the Philippines

Nine field studies, four laboratory/greenhouse/microplot studies, and four socio-economic impact analysis and technology transfer activities are planned for Year 10 at the Asia site in the Philippines. While studies continue to focus on generation, confirmation and fine-tuning of input-reducing technologies in onion and eggplant grown after rice, efforts to disseminate and transfer these technologies are intensified in the proposed activities for Year 10. Studies initially conducted in the laboratory, greenhouse, or microplots will be conducted in the field in preparation for technology transfer and dissemination. Socio-economic impact analysis and search for effective modes of delivery systems will be conducted to enhance widespread adoption of IPM CRSP technologies.

In anticipation of release of funds from the PL 480 proposal (approved in Year 2000) this year, 12 activities are initially being proposed and included in the Year 10 workplan. Most of these studies address additional technology generation and expansion to other parts of the country with rice-based cropping systems. Technologies initially developed at the site will also be disseminated to the expansion areas using PL480 funds. Identification of priority crops, pests, and researchable issues in the expansion areas will be determined through a PA process. High-value crops like mango and abaca will also be included in the PL480 activities as well as generation of transgenic eggplant to manage the fruit and shoot borer.

The IPM CRSP team at the Philippine site is a collaboration of national and international scientists with highly complementary expertise in rice and vegetable IPM. They come from U.S. universities (Virginia Tech, Ohio State, Pennsylvania State), Philippine research and educational institutions (PhilRice, University of the Philippines Los Banos (UPLB), Central Luzon State University (CLSU), Leyte State University (LSU)), international institutions (International Rice Research Institute (IRRI) and Asian Vegetable Research and Development Center (AVRDC)), non-government organizations (NOGROCOMA, site of the demo farm) and farmer-cooperators. Cooperation between the Philippine and Bangladesh sites on management of eggplant pests using genetic and cultural approaches will be continued. IPM CRSP-supported scientist training in graduate and non-graduate programs will also continue in Year 10.

## Field Experiments (On-Farm and PhilRice CES)

### I.1. Integrated Weed Management Strategies in Rice-Onion Systems

a. **Scientists:** A.M. Baltazar – UPLB; J.M. Ramos, E.C. Martin, M.C. Casimero – PhilRice; A.M. Mortimer – IRRI; S.K. De Datta – Virginia Tech.

b. **Status:** Continuing activity

c. **Overall objective:** To develop long and short-term approaches to manage weeds in rice-onion systems and to integrate the different management approaches in each rice and onion crop into a rotation systems approach. **Year 10 objectives: (**1) Identify the best combination of tillage and chemical control methods in stale-seedbed techniques combined with farmer's practice (rice hull burning,tillage, or interrow cultivation) for reduction of *C. rotundus* tuber populations; (2) Determine selective post-plant application methods of glyphosate for control of *C. rotundus* in onion.

**d.** **Hypotheses:** (1) Effect of weed control practices on weed growth during the rice crop can be carried over into the onion crop and vice-versa, and reduces weed control inputs; (2) Significant reductions in *C. rotundus* populations can be made by use of stale-seedbed techniques during fallow periods between rice and onion crops; (3) Selective post-plant glyphosate application methods can increase its efficacy against *C. rotundus* compared to preplant applications.

**e.** **Description of research activity:**

<u>*Impact of stale-seedbed technique on C. rotundus tuber populations*.</u> The study will be conducted in Palestina, San Jose City, where rice hull burning is a traditional cultural practice and in Bongabon, Nueva Ecija where tillage alone (no rice hull burning) is the farmer's practice, for two full cycles of the rice-onion rotation. Stale seedbed techniques after each crop will compare tillage frequency and preplant glyphosate applications in RCBD design. Unweeded and weed-free checks will be included. Plots sizes will be 4 x 5 $m^2$ and the same treatments in each plot will be maintained across crops. The following will be determined: (1) fate of tubers throughout the rice-onion rotation; and (2) the reproductive contribution of surviving plants to tuber populations in response to the stale-seedbed technique. The density of *C. rotundus* tubers and shoots in fixed quadrats in each plot will be counted between treatments prior to the start of the next cropping phase. Crop yields will be taken. Cost-effectiveness of all treatments will be analyzed.

<u>*Selective post-plant applications of glyphosate*.</u> The study will be conducted in Bongabon, Nueva Ecija, where onion is grown in rows on raised furrows. Promising treatments identified from Yr 9 study will be evaluated. Inter-row cultivation (farmer's practice) will be included for comparison. Treatments will be replicated four times in 4 x 5 $m^2$ plots arranged in a RCBD layout. Crop injury (1 = no injury, 9 = 30% or more injury) at 7 to 15 days after treatment (DAT)) and weed control (1 = 100% control, 9 = 60% less control) will be rated visually at 15 to 30 DAT. Weeds from 0.5 x 0.5 m quadrats will be counted by species and fresh weights will be recorded at 30 to 45 DAT and at harvest. Weight of onion bulbs will be taken from a 2 x 5 $m^2$ area at the center of each plot and expressed in t/ha. Analysis of cost-effectiveness of all treatments will be included.

**f.** **Justification:** As much as 90% of potential yields in onion experimental plots are lost due to competition from weeds. While estimates of actual yield losses in farmers' fields are not available, the amount that onion growers spend annually in weeding labor and herbicides, $400/ha or 20% of total production costs, reflects the critical role of weed control in onion production. *C. rotundus,* the most destructive weed in onion, is carried over into the rice crop primarily through the tubers, which can remain viable in the soil for several years. Stale-seedbed techniques prior to crop sowing offer the opportunity to substantially reduce tuber populations and to minimize, if not totally eliminate, the need for post-plant weed control inputs. The effectiveness of stale-seedbed techniques will depend, however, on rapid promotion of tuber sprouting and subsequent kill in which tillage and chemicals will necessarily interact. Identifying the correct combinations for farmer use only can be achieved by knowledge of the dynamics of tuber populations.

Currently available herbicides for weed control in onion are not effective against *C. rotundus*. Glyphosate, which is effective against this weed, is not selective to onion and can only be used as a pre-plant application to avoid crop injury. Preplant applications, however, are too early in the season to control escapes and subsequent regrowths at mid-season and fail to provide adequate season-long control. If glyphosate can be applied post-plant without injury to onion, its efficacy can be increased and season-long control can be obtained.

**g.** **Relationship to other CRSP activities at the site:** This activity will make use of data obtained from activities evaluating effects of cultural practices against soil-borne pests; i.e. rice-hull burning and deep plowing. Data obtained from this activity can be integrated with other intervention practices against soil-borne pathogens including nematodes.

**h.** **Progress to date:**
*Stale-seedbed technique:* Studies on two cycles of the rice-onion rotation have been completed in an onion field where rice hull burning is a traditional cultural practice. Initial results indicate that rice hull burning combined with stale seedbed technique reduced *C. rotundus* tuber populations better than rice hull burning alone.

*Selective post-plant application of glyphosate*: First year studies showed that the shielded sprayer decreased weed growth and reduced handweeding time more significantly than did the rollerbrush or paintbrush. It also took less time to spray than to apply the herbicide with rollerbrush or paintbrush. Second year studies evaluated the efficacy of nozzle shield and interrow cultivation compared to paintbrush, shielded sprayer, and preplant application of glyphosate. Initial results indicate that all postplant applications were more effective than preplant applications.

**i.** **Projected output:** Stale-seedbed technique**:** (1) Reduced *C. rotundus* infestations; (2) Data on population dynamics of *C. rotundus* in tropical cropping systems with different cultural practices.

Post-plant glyphosate application**:** **(**1) Increased herbicide selectivity and efficacy against *C. rotundus*; (2) reduced chemical and cultural inputs.

**j.** **Projected impact:** **(**1) Reduced herbicide use and manual weeding; (2) Reduced production costs and increased profits in onion production.

**k.** **Projected start:** October 1, 2002

**l.** **Projected completion:** September 30, 2003

**m.** **Projected person-months of scientist time per year:** 5-6

**n.** **Budget:** PhilRice – $6,050; VT – $3,175

**I.2. Seasonal Abundance, Incidence of Larval Parasitism, and Effect of Trap Color on Attraction of Onion Leafminer, *Liriomyza trifolii* (Burgess) Adults**

**a.** **Scientists**: G.S. Arida, E.R. Tiongco, B.S. Punzal, C.C. Ravina – PhilRice, E.G. Rajotte – Penn State

**b.** **Status**: Continuing activity (additional activity for *L. trifolii* project)

**c.** **Overall objective:** To determine if naturally occurring biological agents in combination with mass trapping of adult flies can be an alternative management strategies for the management of *Liriomyza trifolii* in onion. **Year 10 objectives:** (1) Determine the level of larval parasitism of leaf miner from different onion –growing provinces in Central Luzon and identify its parasitoids; (2) Determine the effect of trap color as attractant to leaf miner adult flies.

**d.** **Hypothesis**: There are communities of natural enemies (parasitoids, predators) that attack leaf miner in the absence of insecticide applications. These naturally occuring biological control agents help regulate leaf miner populations in the field.

**e.** **Description of research activity**:

<u>*Abundance of leafminer and its parasitoids.*</u> Fields in 4 towns/cities in Nueva Ecija and three each from the provinces of Nueva Viscaya, Pangasinan, and Ilocos Norte will be used as sampling sites. In each town, 2 fields will be sampled; each field will be visited 3 times during the cropping season. Level of damage will be evaluated on 20 randomly selected plants at each sampling time. Damaged leaves (50-100) will be collected at random from each field to assess level of parasitism. Samples will be brought to the IPM-CRSP laboratory for rearing in containers with funnels mounted upside down with attached vials to trap emerging flies or parasitoids. Parasitoids will be identified and percent parasitism will be calculated at each sampling occasion. A record of pest control practices of each farmer at each sampling site will be recorded.

<u>*Comparison of color of traps for attracting leafminer adults*</u> The efficacy of four colors of board: yellow, purple, blue and white (control) to attract adult leaf miner will be compared. The traps will be set out in a 0.5 ha field at the NOGROCOMA/IPM CRSP Demo Farm in Bongabon, Nueva Ecija. Each color, representing a treatment, will be replicated four times in a randomized complete block design (RCBD). Trap catches will be recorded weekly.

**f.** **Justification**: Maximizing natural control is an important principle in IPM. In the Philippines, very limited information on the natural enemies of onion leafminer and their impact on the population dynamics of the pest is known.

Knowing the most efficient trap color is important in surveillance and monitoring system. These are useful in determining the best time to apply interventions or if interventions are needed. The use of sticky traps and collection of adults using sweep nets was reported to be a good management tool in an IPM program against leaf miner in some countries.

**g.** **Relationship to other CRSP activities at the site**: This study will augment other studies on insect pests of onion and on the development of IPM strategies for this pest.

**h.** **Progress to date**: The species of leaf miner attacking onion was recently identified as *Liriomyza trifolii* (Burgess). Dr. Sonja J. Scheffer (USDA-ARS, Beltsville, MD, 20705 USA) identified the specimens collected by IPM-CRSP staff from several onion growing provinces in Central Luzon, Philippines. Initial results of our study (2001) between sprayed (Chlorpyrifos+BPMC) and unsprayed plots showed no significant differences on the number of adult flies caught in the sticky board traps, number of larvae and feeding punctures from weekly collected onion plants. The level of larval parasitism and number of predators were lower in the sprayed as compared to unsprayed plots. This shows that insecticide applications against leaf miner was not effective but detrimental to its natural enemies.

Larvae collected from other vegetables (string beans, pechay and tomato) during the months of October and November showed very low levels of parasitism (0-7.6%). Less than one percent parasitism was recorded from larvae collected from heavily sprayed pechay crop.

**i.** **Projected output**: (1) Information on seasonal abundance of leafminer and its parasitoids from different locations; (2) Identification of parasitoids and other natural enemies and its impact on leafminer population in the Philippines.

**j.** **Projected impact**: Reduced insecticide use in onion against leafminer.

**k.** **Projected start**: October 2002

**l.** **Projected completion**: September 2003

**m.** **Projected person-months of scientist time per year**: 5

**n.** **Budget**: PhilRice – $ 5,610; Penn State – $2,164

### I.3 Influence of Host Plant Resistance and Grafting on the Incidence of Bacterial Wilt in Eggplant

**a.** **Scientists**: N.L. Opina – UPLB; R.T. Alberto – CLSU; S.E Santiago – PhilRice; R.M Gapasin – LSU; S.A. Miller – Ohio State

**b.** **Status**: Continuing activity with new subactivity at LSU

**c.** **Overall objective**: To determine the effectiveness of host plant resistance and grafting against bacterial wilt in eggplant. **Year 10 Objectives:** (1) To continue to identify eggplant cultivars with resistance to *Ralstonia solanacearum* strains and root-knot nematode; (2) To determine the most compatible root stock and scion combination in managing bacterial wilt; (3) To evaluate the effectiveness of grafting in reducing the incidence of bacterial wilt in 3 to 5 locations in Pangasinan and Nueva Ecija provinces; (4) To evaluate lines/varieties/hybrids of eggplant for resistance to root-knot nematode.

**d.** **Hypotheses**: (1) Grafting of bacterial wilt and root-knot nematode-resistant cultivars of eggplant with susceptible cultivars will enhance tolerance to bacterial wilt and decrease incidence of the disease; (2) Using eggplant varieties with resistance to root-knot nematode could reduce the incidence of bacterial wilt.

**e.** **Description of research activity**: Eggplant cultivars known to be resistant to bacterial wilt will be screened for resistance to strains of *Ralstonia solanacearum* isolated from major eggplant-growing areas. Eggplant varieties, lines and germplasm will be screened for resistance to root-knot nematode under greenhouse conditions. Various root stock – scion combinations will be evaluated for resistance to bacterial wilt both in the greenhouse and disease nursery. Grafting will be done at PhilRice (CES) using technology from AVRDC and IPM CRSP Bangladesh site. One-month-old grafted and non-grafted eggplant seedlings will be transplanted into naturally bacterial wilt-infected farmer's fields in Nueva Ecija and Pangasinan. The plants will be grown in 4 x 5 m cultivated – mulched plots and arranged in RCBD with four replications. Incidence of bacterial wilt will be monitored in each plot at weekly intervals. Yields will be recorded.

Seeds of different lines/ varieties/ hybrids of eggplant will be acquired from different sources. The most virulent strain of *Ralstonia solanacearum* will be obtained from N. Opina's laboratory at IPB. The root-knot nematode will be mass-produced or cultured in susceptible tomato plants. Thirty-day old eggplant seedlings will be transplanted individually into plastic pots filled with sterilized soil. At 45 days after transplanting the plants will be inoculated with 1,000 eggs of the nematode. The different lines/ varieties/ hybrids will be replicated 5 times and placed in the screenhouse. Data will be collected at 45 days after inoculation. Gall and egg mass rating index will be recorded following the rating scale of: 1= 1-2 galls or egg masses; 2 = 3-10 galls or egg masses; 3= 11-30 galls or egg masses; 4= 31-100 galls or egg masses and 55= more than 100 galls or egg masses. Based on this index the resistance rating of the different lines/ varieties/ hybrids will be determined as follows: 0 – 0.9= Resistant; 2.0-2.9= Moderately Resistant; 3.0 – 3.9= Moderately Susceptible and 4.0-5.0= Susceptible.

**f.** **Justification**: Bacterial wilt, caused by *Ralstonia solanacearum* and root-knot nematode caused by *Meloidogyne incognita* are destructive diseases affecting solanaceous crops in tropical, subtropical and even in temperate regions of the world. These pathogens are soil-borne, with a wide host range and can survive in the deeper layers of the soil. The use of resistant varieties in combination with cultural management, e.g. grafting onto bacterial wilt-resistant rootstock, can further reduce the incidence of bacterial wilt of eggplant in the field.

Eggplant cultivars believed to be wilt resistant succumb to bacterial wilt when planted in root-knot infested soil. The nematode predisposes the plants to bacterial infection. It is therefore important to screen eggplant varieties for resistance to root-knot to be able to manage bacterial wilt disease.

**g.** **Relationship to other CRSP activities at the site:** The management of bacterial wilt in eggplant will complement management options being developed against eggplant leafhopper (*Amrasca biguttula*) and fruit and shoot borer (*Leucinodes orbonalis*). Its integration with insect pest management is essential to success of eggplant production in the country.

**h.** **Progress to date:** Promising grafted lines and commercial cultivars were evaluated in farmers' fields. Two-year field data showed that grafting increased tolerance of susceptible commercial cultivars and increased yields over ungrafted plants.

**i.** **Projected output:** Identification of the most resistant and best grafting combinations of eggplant against bacterial wilt and root-knot nematode.

**j.** **Projected impact:** Reduced disease incidence, reduced fungicide use, higher yields and profits.

**k.** **Projected start:** October 1, 2002

**l.** **Projected completion:** September 30, 2003

**m.** **Projected person-months of scientist time per year:** 4

**n.** **Budget:** PhilRice/LSU – $ 0; PL 480 – $ 8,250; OSU – $2,709

### I.4. Combined Resistance of Eggplant, *Solanum melongena* L., to the Leafhopper *Amrasca biguttula* (Ishida) and Eggplant Borer, *Leucinodes orbonalis* (Guenee)

**a.** **Scientists:** M. T. Caasi-Lit, R.G. Maghirang, M.A.A. Capricho – UPLB; N.S. Talekar – AVRDC; E.G. Rajotte – Penn State

**b.** **Status:** Continuing activity

**c.** **Overall objective:** Develop eggplant populations with combined resistance to *Amrasca biguttula* and *Leucinodes orbonalis*. **Year 10 objectives: (**1) Conduct replicated trials at

UPLB and PhilRice; and (2) Screen crosses obtained from Year 8 and Year 9 hybridization work.

d. **Hypotheses: (**1) There are available sources of resistance of eggplant to leafhopper and eggplant borer that could be utilized to help regulate the populations of these pests below damaging levels; (2) The mechanism of resistance of eggplant against leafhopper is a combination of antixenosis, antibiosis and tolerance; and (3) Use of resistant eggplant populations is an effective means of managing these two major insect pests.

e. **Description of research activity:** Eggplant accessions/varieties/lines that are highly and moderately resistant and highly and moderately susceptible to the two major insect pests will be identified (selection of at least five resistant and susceptible entries). They will be planted in three 1 m row plots (unreplicated) during the regular screening trial.

In another field, the selected 22 promising entries for the replicated yield trial will be planted in five 5 m row plots in three replications arranged in RCBD. All the entries will be rated for pests and disease resistance especially bacterial wilt and phomopsis blight. Agronomic characters will also be assessed.

The crosses made in Y8 and Y9 will be screened in the field for resistance reaction. Further crossing and backcrossing will be done to increase the level of pest resistance or yield. For Y10, the bulk of work will be on hybridization and field resistance testing.

As suggested during the 2001 review and evaluation, fruits of the different entries will be tested at the Post Harvest Training and Research Center for consumer preference and taste tests.

The Principal Investigator will be trained for 2 months at the Department of Entomology at Penn State University in collaboration with Dr. Ed Rajotte and a biochemist from PSU to further study "Leaf trichomes as a resistance factor in eggplant, *Solanum melongena* L. against the leafhopper, *Amrasca biguttula* (Ishida)". The study will focus on the morphological and biochemical components in leaf trichomes of eggplant for leafhopper resistance. This will be determined through biochemical analysis and electron microscopy of the nature of trichomes (arboriform-type) and trichome exudates.

f. **Justification:** While leafhopper was observed to cause significant yield loss at early vegetative stage of eggplant growth, the eggplant borer is becoming the major pest of eggplant at early flowering to fruiting stages. The larva damages the plant at early vegetative stage by boring into the shoots. Damage is most serious at the flowering to fruiting stage when larvae bore into the fruits causing significantly heavy losses or even total crop yield loss. Screening leafhopper resistant varieties for resistance to the eggplant borer is the first attempt to identify and develop eggplant varieties with combined resistance to these two major insect pests. The use of resistant varieties would also help minimize yield loss and are environmentally friendly. Specifically, the use of resistant varieties is safe to non-target pests, enhances establishment of parasites and predators, thus a safer alternative than heavy pesticide use.

g. **Relationship to other CRSP activities at the site:** Use of resistant varieties can complement other control measures in eggplant against this pest such as use of biological control agents (*Trathala, Chelonus, Cotesia* against eggplant borer and *Campylomma livida* against the leafhopper) and use of cultural management practices (fruit removal and sanitation).

h. **Progress to date:** Host plant resistance studies in eggplant against the eggplant leafhopper have been done at the Institute of Plant Breeding UPLB in 1987 and improved IPB lines, IPB-GS1 and IPB GS2, were developed and included in the screening trial and to be included as one of the entries for hybridization work. Screening eggplant for resistance to the eggplant borer only started in 1997 and several accessions from NPGRL were screened in the field and 15 entries showed moderate resistance against the borer. Screening protocols for the eggplant borer are being developed, modified and improved. With funding from IPM-CRSP, several farmers and commercial varieties of eggplant were screened and showed promising response against these two major insect pests. Further work is being done on the development of eggplant populations with combined resistance to leafhopper and shoot and fruit borer.

i. **Projected output: (**1) Identification of sources of resistance or genetic stocks of eggplant with resistance to leafhopper and to the eggplant borer; (2) Field techniques and procedures to screen eggplant genotypes for resistance to the pests and basic information on host plant resistance; (3) Techniques to incorporate borer resistance to commercially grown eggplant varieties.

j. **Projected impact:** Reduced or no pesticide use as HPR-based pest management strategy capitalizes on sound, safe and environmentally friendly approaches.

k. **Projected start:** October 1, 2002

l. **Projected completion:** September 30, 2003

m. **Projected person-months of scientist time per year:** 3

n. **Budget**: PhilRice – $ 0; P.L. 480 – $ 9,020; Penn State – $3,546

### I.5. Management of the Eggplant Fruit and Shoot Borer *Leucinodes orbonalis* (Guenee): Evaluation of Farmers' Indigenous Practices

a. **Scientists**: G.S. Arida, C.C. Ravina, B.S. Punzal – PhilRice; E.G. Rajotte -Penn State

b. **Status**: New activity

**c.** **Overall objective**: To develop safe and economical management strategies against the eggplant shoot and fruit borer. **Year 10 objective:** To evaluate farmers' indigenous pest management practices against the eggplant fruit and shoot borer.

**d.** **Hypothesis**: Some farmer's management practices against the eggplant fruit shoot and fruit borer are effective and comparable if not better than the popular method of using 60 to 80 insecticide sprays in a season.

**e.** **Description of research activity**: Onion cultivar Red Pinoy will be grown at the PhilRice Central Experiment Station (CES). Treatments will be arranged in randomized complete block design replicated 4 times. The treatments to be compared with farmer's practices are: a) Planting marigold (*Tagetes* sp.) with eggplant; b) Weekly application of burned rice hull by dusting; c) weekly removal of damaged fruits and shoots (based on previous CRSP results); d) weekly spray of insecticides and e) untreated control. The number of damaged fruits and shoots will be recorded weekly beginning at 2 weeks after transplanting. Yields will be recorded at harvest.

Three sex pheromone baited traps will be installed in the field to monitor adult population density. The relationship between sex pheromone trap catches and damaged shoots and fruits will be studied also.

**f.** **Justification**: *L. orbonalis* is the most serious insect pest of eggplant in Asia including the Philippines. Farmers usually spray several times a week in order to manage this pest, seldom with success. Surveys showed that farmers in the Philippines sprayed 58 times on the average while it was 80 times in Bangladesh. This insecticide misuse resulted in high cost of production and pesticide hazards to farmers, consumers and the environment. It is therefore necessary to find an alternative method in managing this pest. Our evaluation studies on use of a net barrier against this pest showed that it may not be economical and not acceptable to most farmers because the pest can still infest the crop inside the net.

In some areas in the Philippines some farmers observed that repellant crop like *Tagetes* sp. protected their eggplant against insect pests resulting in good yields. In another area, farmers reported using the ash from burned rice hull to repel pests attacking eggplant by applying burned rice hull as dust to eggplant leaves. If these management practices of some farmers are proven effective, these will be economical, safe and acceptable to all eggplant farmers.

**g.** **Relationship to other CRSP activities at the site**: This activity complements the other studies on management of the eggplant fruit and shoot borer, ie. cultivar screening for leafhopper resistance.

**h.** **Progress to date**: Past studies at IPM-CRSP Philippine site showed that weekly removal of damaged shoots and fruits is a good alternative to high frequency of insecticide sprays against the eggplant fruit and shoot borer. The use of net barrier did not prevent the borer from infesting the eggplant.

i. **Projected output**: An alternative management strategy against the eggplant fruit shoot and fruit borer.

j. **Projected impact**: Reduction in costs and hazards caused by insecticide applications.

k. **Projected start**: October 2002

l. **Projected completion**: September 2003

m. **Projected person-months of scientist time per year**: 4

n. **Budget:** PhilRice – $ 3,260; Penn State – $ 3,426

**I.6. Management of Anthracnose (*Colletotrichum gloeosporioides*), a Disease of Increasing Importance in Onion**

a. **Scientists:** R.T. Alberto – CLSU; M.S.V. Duca – PhilRice, S.A. Miller – Ohio State

b. **Status:** New activity

c. **Overall objective:** To develop cost-effective management strategies against anthracnose disease in onion. **Year 10 objectives:** 1) Determine effective timing, rates and frequency of application of commercially available fungicides against anthracnose disease of onion, 2) Determine which among the fungicides have protective and therapeutic effects against the anthracnose pathogen.

d. **Hypothesis:** Currently available fungicides, when combined with other control measures, can be effective against anthracnose.

e. **Description of research activity:** The experiment will be conducted at PhilRice Central Experiment Station with cv. Red Pinoy, a susceptible variety. Seedlings will be transplanted into raised beds with eight rows per bed in six 20 $m^2$ plots arranged in RCBD with five replications. The treatments are: (1) No intervention; (2) Application of protectant fungicide (Maneb) 2 weeks after transplanting at recommended rae and frequency of application; (3) Low nitrogen levels to be determined after consultation with soil scientists; (4) Wider plant spacing and positioning of rows in the direction of the wind, (5) Combination of treatments 2,3, and 4; and (6) Combination of treatments 2,3, and 4 but reduced fungicide application. Plants will be sprayed with 14 day-old spore suspension of *C. gloeosporioides* (spore density of $2.5x10^6$ with 10 drops of Tween 80/liter of suspension). The inoculated plants will be covered with plastic mats overnight (removed the following morning) for 3 consecutive days to induce infection. Mist or overhead irrigation will be used to simulate rainfall and to maintain 100% relative humidity. Plants in all plots will be managed according to recommended cultural and management practices. Plants will be evaluated for % disease incidence, % disease severity and crop stand at weekly intervals. Based on the disease proportion, AUDPC will be computed. Onion bulbs will be harvested from $1m^2$ area at the center of each plot. Bulbs will be classified into small, medium and large and then weighed.

**f.** **Justification:** One of the most destructive diseases of onion in the Philippines is anthracnose and the use of fungicides is the only effective means of control so far. In the absence of resistant varieties, cultural control and other disease control measures, farmers have no choice but to use chemical methods. There is a need to know optimum rates, timing and frequency of application to address the negative impact of using chemical fungicides and to develop a strategy of using fungicides effectively with less environmental and health effects and also to avoid development of pathogen resistance to fungicides.

**g.** **Relationship to other CRSP activities at the site:** Results of this experiment will complement the activity on screening for onion cultivars resistant to anthracnose.

**h.** **Progress to date:** Not applicable (new activity)

**i.** **Projected output:** Identification of the most effective rates, and timing and frequency of application of fungicides to manage anthracnose disease in onion.

**j.** **Projected impact:** Reduced fungicide use, reduced hazards of pesticide application and less farm input costs.

**k.** **Projected start:** October, 2002

**l.** **Projected completion:** September, 2003

**m.** **Projected person-months of scientist time per year:** 3

**n.** **Budget:** PhilRice – $ 1,985; OSU – $ 2,835

### I.7. Management of *Spodoptera litura* (F.) and *S. exigua* (Hubner) by Mass Trapping and Timing of Interventions in Farmers' Fields

**a.** **Scientists:** G.S. Arida, B.S. Punzal, C.C. Ravina - PhilRice, N.S. Talekar – AVRDC; E.G. Rajotte - Penn State

**b.** **Status:** Continuing activity

**c.** **Overall objective:** To develop monitoring and surveillance tools for effective timing of interventions against cutworm and armyworm in onion and other vegetables. **Year 10 objective**: To evaluate the effect of mass trapping of male *S. litura* and *S. exigua* moths and timing of interventions based on sex pheromone trap catches on pest damage and yield in onion and to compare this strategy with farmers' pest management practices.

**d.** **Hypothesis:** Combined mass trapping and timing of interventions based on trends in sex pheromone trap catches will reduce frequency of insecticide applications in onion and other vegetables to manage *S. litura* and *S. exigua.*

**e.** **Description of research activity:** Onion cultivar Red Pinoy will be grown in several farmers' fields in Nueva Ecija. In each field, three - 5m x 10m areas selected randomly will be used as researchers' plot. An equivalent area will be used as farmers' practice plots. Application of intervention against *S. litura* and *S. exigua* in the researchers' plots will be based on the trend in sex pheromone trap catches while the farmer cooperator will be allowed to do his own pest management practices. All pest management activities of each farmer cooperator will be recorded. Density of larvae and damaged leaves will be monitored every 2 weeks on 10 randomly selected plants per plot. Yields will be recorded and compared at harvest. All agronomic practices: weeding, water and fertilizer management will be done according to farmers practice.

**f.** **Justification:**An efficient monitoring and surveillance system will reduce, if not prevent, insecticide misuse in onion.

**g.** **Relationship to other CRSP activities at the site:** An important component in the management of *S. litura* and *S. exigua* in onion and other vegetables.

**h.** **Progress to date:** Results of preliminary study (2001) showed that a single application of insecticide at 5 days after a peak in trap catches had significantly lower damaged leaves and number of larvae of defoliators than the unsprayed control. Yields in plots with single application of insecticide were comparable with those of weekly-sprayed plots. Both treatments had significantly higher yields than untreated control plants. This indicates that spraying more than once in a season not be necessary and that a large amount of insecticides used to control *S. litura* and *S. exigua* in onion is applied unnecessarily and thus wasted.

**i.** **Projected output:** Effective timing of insecticide application against *S. litura* and *S. exigua* in onion and other vegetables.

**j.** **Projected impact**: Reduced if not prevent insecticide misuse in onion and other vegetables.

**k.** **Projected start:** October 2002

**l.** **Projected completion**: September 2003

**m.** **Projected person-months of scientist time per year:** 4

**n.** **Budget:** PhilRice – $ 1,760; Penn State – $ 2,825

### 1.8. Effect of Level of Defoliation at Different Crop Ages on Yield of Onion

**a.** **Scientists**: G.S. Arida, C.C. Ravina, B.S. Punzal - PhilRice; E.G. Rajotte - Penn State

**b.** **Status**: Continuing activity (with modifications depending on 2001and 2002 results)

**c.** **Overall objective**: To determine leaf damage level and yield loss relationships in onion. **Year 10 objective**: To determine level of leaf damage at different crop ages and effect on yield.

**d.** **Hypothesis**: The onion plant can compensate for damage caused by leaf feeding insects at certain levels of defoliation.

**e.** **Description of research activity**: Onion cultivar Red Pinoy will be grown at the NOGROCOMA/IPM CRSP Demo Farm in Bongabon and at a farmer's field in Lomboy, Talavera, Nueva Ecija. Artificial defoliation will be done at 15, 30, 45 and 60 days after transplanting (DAT). For each defoliation period there will be 4 levels of defoliation: 0, 1, 2, and 3 leaves and flag leaf totally removed from each plant. Artificial defoliation will be accomplished by cutting off leaves to get the desired level of damage. There will be 4 replications in a randomized complete block design (RCBD). The following data will be recorded: (1) Damaged leaves on 10 randomly selected plants at 6 and 7 WAT (leaf miner); 8 and 10 WAT ( *Spodoptera* and *Helicoverpa*) (2) No. of larvae of defoliators at 8 WAT, (3) weight of bulbs (10 randomly selected bulbs per plot); and (4) sugar content, acidity, and size of bulbs.

**f.** **Justification**: There is a big information gap on pest damage and yield loss relationships in vegetables like onion. Defoliators are probably the most important insect pests of onion based on farmers' frequency of insecticide spray. This is due to the highly visible and easily recognized damage caused by these pests. Farmers perceive that this damage, regardless of level, will cause significant loss in yield. This perception contributes to the misuse of pesticides in vegetables. A better understanding of pest damage and yield loss relationship is vital for improving pest management decisions.

**g.** **Relationship to other CRSP activities at the site**: Damage caused by *Spodoptera* spp. and *Helicoverpa* sp. will be simulated in this study. This is part of the program for the development of IPM strategies against these pests.

**h.** **Progress to date**: Initial results (1999) showed that bulb weight was not affected when the crops are at early vegetative stage (15 and 30 days after transplanting) with defoliation levels of up to 50%. Simulated damage of up to 75% at the early stage of crop growth (15 DAT) had no effect on bulb size and weight as recorded in Talavera and Bongabon. Fifty percent defoliation at 30 DAT in Bongabon had no effect on bulb size and weight. The middle stage of crop growth (45 DAT) was sensitive to any level of artificial defoliation in terms of yield, bulb maturity, and plant height. Results suggest that onion has the ability to compensate for early season damage caused by insect defoliators.

i. **Projected output**: Identification of damage and age of crop that is critical to yield loss in onion.

j. **Projected impact**: Reduced insecticide application inputs and health hazard.

k. **Projected start:** October 2002

l. **Projected completion**: September 2003

m. **Projected person-months of scientist time per year**: 4

n. **Budget:** PhilRice – $ 5,060; Penn State – $ 3,847

### I.9. Biological Control of Soil-borne Pathogens Using *Trichoderma* sp. in Rice-Vegetable Systems

a. **Scientists:** R. M. Gapasin – LSU; S.A. Miller – Ohio State; R.T. Alberto - CLSU

b. **Status:** Continuing activity (field study)

c. **Overall objective:** To develop management strategies against soil-borne pathogens using biological control agents. **Year 10 objectives: (**1) Evaluate selected biocontrol agents against fungal pathogens of onion; (2) Develop delivery systems of *Trichoderma* for the control of damping-off disease of onion seedlings and pink root disease.

d. **Hypotheses:** (1) Biocontrol agents are effective in reducing diseases of onion caused by soil-borne fungi and root-knot nematode; (2) Currently available methods are effective for delivery of active biocontrol agents into onion

e. **Description of research activity:** One study will be conducted at the NOGROCOMA/IPM CRSP demo farm in an area naturally infested with pink root (*Phoma terrestris*) in Bongabon, Nueva Ecija. Plots will be 3m x 3m arranged in RCBD and replicated 4 times. Treatments are: (1) Uninoculated control; (2) Phoma alone; (3) Maneb + *Phoma*; (4) T5 + *Phoma* (Root dipping); (5) Tv + *Phoma* (Root dipping) (6) T5 + *Phoma* (Root dipping and Broadcasting); (7) Tv + *Phoma* (Root dipping and Broadcasting); (8) T5 alone; (9) Tv alone.

A second study will be conducted at the PhilRice Central Experiment Station in 3m x 3m plots infested *with Sclerotium, Fusarium or Rhizoctonia*. Root dipping and root dipping + broadcasting of *Trichoderma viride and Trichoderma* sp. (T5) will be done. Treatments will be replicated 4 times and arranged in RCBD: (1) uninoculated control; (2) Maneb + *Sclerotium*; (3) Maneb + *Fusarium*; (4) Maneb + *Rhizoctoni*a; (5) *Sclerotium* alone; (6) *Fusarium* alone (7) *Rhizoctonia* alone; (8) Tv alone; (9) T5 alone; (10) Tv (Root Dipping [RD]) + *Sclerotium*; (11) Tv (RD) + *Fusarium;* (12)Tv (RD) + *Rhizoctonia*; (13) T5 (Root Dipping [RD]) + *Sclerotium*; (14) T5 (RD) + *Fusarium*;

(15)T5 (RD) + *Rhizoctonia*; (16)Tv [RD+Broadcasting (B) + *Sclerotium*; (17) Tv [RD + Broadcasting (B) + *Fusarium*; (18) Tv [RD+Broadcasting (B) + *Rhizoctonia*; (19) T5 [RD+Broadcasting (B) + *Sclerotium;* (20) T5 [RD + Broadcasting (B) + *Fusarium*; (21) T5 [RD+Broadcasting (B) + *Rhizoctonia.*

Data on percent damping off will be taken at monthly intervals and weight of onion bulbs will be recorded at harvest.

f. **Justification:** *Rhizoctonia solani, Fusarium sp., Sclerotium rolfsii and Phoma terrestris* are the principal soil-borne fungi causing diseases in onion in the Philippines. None of these pathogens can be controlled effectively by pesticides or by use of resistant varieties. The biocontrol agents selected for this study have shown activity in other systems and have the potential for controlling these pathogens.

g. **Relationship to other CRSP activities at the site:** This study will complement studies on evaluation of biological control agents against root knot nematode and other soil-borne pests.

h. **Progress to date:** Microplot experiment showed the potential of *T. viride* and *Trichoderma* sp. (T5) against the damping-off pathogens of onion.

i. **Projected outputs:** (1) Identification of potential biological control agents against soil borne pathogens; (2) Identification of the most effective delivery and optimum concentration of the antagonists

j. **Projected impact:** Non-chemical control of soil borne diseases of onion

k. **Projected start:** October 2002

l. **Projected completion:** September 2003

m. **Projected person-months of scientist time per year:** 3

n. **Budget:** PhilRice/LSU – $ 5,450; OSU – $3,969

## I.10. Biological Control Of *Meloidogyne graminicola* and Other Soil Borne Pathogens in Rice-Vegetable Systems Using Specific Biological Control Agents

a. **Scientists:** E.B. Gergon– PhilRice; R.M. Gapasin - LSU; M. Brown – UPLB; S.A. Miller – Ohio State

b. **Status**: Continuing activity

c. **Overall objectives: (**1) Evaluate selected biocontrol agents for activity against root knot nematode of onion; (2) Determine effects of biocontrol agents on the growth and yield of onion under field conditions. **Year 10 objectives:** Evaluate VAM, *Bacillus* sp. and organic materials for control of pink root and root-knot nematode infesting onion.

**d.** **Hypotheses**: (1) Biocontrol agents are effective in reducing diseases of onion caused by soil-borne diseases and by root knot nematode; (2) Mycorrhizae deter root-knot infection and improves plant vigor (by enhancing P and Co uptake); (3) VAM and organic composts are effective in reducing root-knot disease in onion and can enhance nutrient uptake thus improve plant vigor; (4) Currently available methods and rates of application are effective against root-knot nematode as well as pink root disease of onion.

**e.** **Description of research activity:**

*Influence of VAM fungi on growth and yield of onion in root-knot infested field.* Mixture of VAM fungi will be applied on seedbed. Plants inoculated with mixture of different species of VAM fungi will be tested against *Meloidogyne graminicola* on Yellow Granex and Red Creole onions in the field. Different rates of P will be applied in the field to determine the influence of VAM fungi on P uptake of the plants.

*Influence of VAM fungi on growth and yield of onion in pink root-infested soil.* Mixture of VAM fungi will be applied on seedbed. Plants inoculated with mixture of different species of VAM fungi will be tested against pink root disease of Yellow Granex and Red Creole onions in the field. Different rates of P will be applied in the field to determine the influence of VAM fungi on P uptake of the plants.

*Comparative evaluation of Bacillus sp and VAM fungi for their effectiveness against M. graminicola.* Mixture of VAM fungi will be applied on seedbed. Transplants will be treated with *Bacillus* sp. by root dipping. Treated plants will be grown in root-knot infested field. Data on nematode counts at monthly intervals will be collected. Growth and yield parameters will be measured at harvest.

*Effect of VAM combined with organic materials for control of root-knot nematode in onion*. (Microplot study to be conducted at Leyte State University) Microplots measuring 1 x 25 m will be infested with *M. graminicola* eggs. Nematode population will be increased by planting susceptible rice cultivar UPLRi 5. Rice plants will be harvested 60 days after planting and the initial nematode populations will be determined in each plot. The following treatments will be used: (1) VAM alone; (2) Nematode (N) alone; (3) Nematode + VAM; (4) VAM + composted rice straw + N; (5) VAM + composted sawdust + N; (6) VAM + chicken manure + N; (7) VAM + cow manure + N; (8) Nematicide (Nemacur); (9) untreated control. The treatments will be replicated three times and arranged in RCBD. Data on biomass, number of galls, nematode population in roots and in soil, VAM spore count, and percentage VAM infection will be gathered.

**f.** **Justification:** *Meloidogyne graminicola* is an important pathogen of onion causing root-knot disease. Since the use of nematicides is impractical and uneconomical for most farmers in the Philippines and resistant onion varieties are not available, it is important to find alternatives such as use of soil amendments that will not only control nematodes but also improve growth and yield of the crop. VAM can replace 50% to 60% of fertilizer rates in other crops. As shown in previous studies, VAM did not only reduce nematode populations but also improved seedling growth under greenhouse conditions.

g. **Relationship to other CRSP activities at the site:** Results of this experiment will complement the other management strategies against root-knot disease of onion.

h. **Progress to date:** VAM has shown great potential in improving growth of onion even in the presence of nematodes. Plants treated with mycorrhizae were taller with greater leaf and root biomass.

i. **Projected output: (**1) Identification of an alternative method of nematode management in rice-onion systems; (2) Additional method of improving seedling establishment in onion; and (3) Information on the effect of VAM on fertilization requirement of onion.

j. **Projected impact:** (1) Identification of additional non-chemical means of controlling soil-borne pathogens in onion; (2) Production of healthy seedlings ready for transplanting in the field; and (3) Reduced fertilizer rates for onion.

k. **Projected start:** October 1, 2002

l. **Projected completion:** September 30, 2003

m. **Projected person-months of scientist time per year:** 2-4

n. **Budget:** PhilRice/LSU – $ 7,260; OSU – $3,969

## I.11. Effect of Nitrogen on Bulb Rot Incidence in Onion During Storage

a. **Scientists:** D.T. Eligio, R.T. Alberto – CLSU, S.A. Miller – Ohio State

b. **Status:** New activity

c. **Overall objective:** To determine the influence of nitrogen on bulb rot during storage

d. **Hypothesis:** High nitrogen application enhances incidence of rot during storage.

e. **Description of research activity:** Onion seeds cv. Yellow Granex and Red Creole will be sown. Seedlings will be raised in exposed elevated seedbeds. The seedlings will be transplanted into a well-prepared paddy field 30 days after emergence. Three uniform paddies will be used to represent replication. Uniformity will be based on elevation, size and soil texture. Soil samples will be collected to determine the physical and chemical properties of the experimental area prior to land preparation. Two to three plowings and harrowings will be done. Each paddy shall be divided into 2 main plots for the varieties. Each main plot shall be further subdivided into 4 sub-plots for the nitrogen levels as follows: Control (no fertilization), 50 kg N/ha, 100 kg N/ha and 200 kg N/ha. The total amount of the fertilizer will be split. The first half will be broadcast and incorporated into the soil during the final harrowing, second half will be applied at bulb-initiation (about 90 days after sowing). Other cultural practices will be employed following the recommendation. Time of harvest will be determined using a combination of the following maturity indices: computation (120 days after sowing the seeds), softening of the neck, topping of the leaves and change in the color of the leaves. Top portion will be trimmed leaving 2 cm from the bulb shoulder. Medium-sized bulbs will be placed in the net bags with a net capacity of 20 kg and stored under ambient and cold storage condition. Five packages will be used per treatment combination. The experiment in the field will be set-up following split-plot design in Completely Randomized Block Design with 3 replications. The treatments are varieties and N fertilization. Factorial experiment in Completely Randomized Design with 5 replications will be used during storage. The treatment combinations are: variety x rate of fertilization x storage condition. The following data will be gathered: (1) physical and chemical properties of the soil; (2) number of days from storing to rot incidence; (3) incidence of rotting; (4) rot-causing pathogen; (5) incidence of sprouting.

f. **Justification:** Growers normally apply excessive amounts of fertilizer especially nitrogen to produce large bulbs without considering the vulnerability of onion to infection to rot-causing pathogens.

g. **Relationship to other CRSP activities at the site:** The project will complement the studies on biological control of soil borne pathogens by determining the degree of sensitivity of bulbs applied with nitrogen in fields without biological control.

h. **Progress to date**: Not applicable (new activity)

i. **Projected output:** Increased bulb yield due to N with less vulnerability to rotting during storage.

j. **Projected impact**: Higher income for onion growers

k. **Projected start**: September 2002

l. **Projected completion**: October 2003

m. **Projected person-months of scientist time per year**: 4

n. **Budget:** PhilRice – \$ 0; P.L. 480 – \$ 6,050; OSU – \$ 2,079

## LABORATORY, GREENHOUSE, AND MICROPLOT EXPERIMENTS

### II.1. Biology, Life Cycle, and Mass Rearing of *Spoladea recurvalis* as Biocontrol Agent Against *Trianthema portulacastrum*

**a.** **Scientists:** A. M. Baltazar – UPLB; E. C. Martin, M. C. Casimero, J. M. Ramos – PhilRice; S. K. De Datta, L. T. Kok – Virginia Tech; E.G. Rajotte – Penn State

**b.** **Status:** Continuing

**c.** **Overall objective:** To determine the efficacy of *S. recurvalis* as biological control agent against *T. portulacastrum*. **Year 10 objectives:** (1) Study the biology and life cycle of *S. recurvalis* in relation to the host plant, *T. portulacastrum*; (2) To develop mass-rearing techniques of *S. recurvalis*.

**d.** **Hypothesis:** Augmenting populations of natural enemies of *T. portulacastrum* can effectively reduce populations of this weed in onion fields.

**e.** **Description of research activity:**

<u>Rearing of *S. recurvalis*</u>. Larvae and eggs of *S. recurvalis* will be collected from onion fields in Bongabon, Nueva Ecija and will be reared in the laboratory for use in various studies. Rearing will be done in screen cages and plastic trays and will be covered with fine screen in the laboratory at room temperature (27C). Food will be supplied to the larvae in the form of fresh *T. portulacastrum* obtained from plants grown in the green house. The larvae will be allowed to pupate in cages and trays and the pupa will be kept in open trays inside the screen cages until adults emerge. Adults will be fed with diluted honey and allowed to mate and lay eggs inside cages containing potted *T. portulacastrum*.

<u>Biology of *T. portulacastrum*</u>. Biology, growth and developmental behavior of *T. portulacastrum* will be studied to determine its growth stages that are susceptible for control. Days after emergence, days to flower, number of leaves, height, number of seeds produced and biomass will be gathered.

<u>Degree of damage.</u> Larvae in increasing numbers (1, 5, 10, 25, and 50) will be used to determine the amount of *T. portulacastrum* leaves that will be consumed by larvae beginning at the second instar until they pupate. Each group will be given uniform fully expanded leaves of *T. portulacastrum.* A second study will involve increasing numbers of larvae (1, 5, 10, 25, and 50) feeding on whole plants.

<u>Host preference test</u>: Host preference test will be conducted on several weeds and crops, normally grown in Bongabon, Nueva Ecija to determine host specificity of *S. recurvalis.*

<u>*Oviposition test:*</u> Same weed and crop species that will be used in then host specificity tests will be used in oviposition test. Newly emerged adults will be placed inside each cage containing a specific weed or crop. Daily observation will be made on site of egg oviposition.

**f.** **Justification:** In the Philippines, only two herbicides are available for selective control of *T. portulacastrum*. This weed is controlled largely by handweeding and cultivation that are costly, time, and labor consuming. In onion fields at the NOGROCOMA/IPM CRSP Demo Farm, *S. recurvalis* has been observed in abundance, feeding voraciously on *T. portulacastrum* for the past several seasons during fallow periods between onion crops. If natural populations of this insect can be augmented with mass-reared larvae and/or adults and released into onion fields at the most competitive stages of the weed, its populations can be reduced to levels that will not reduce yields.

**g.** **Relationship to other CRSP activities at the site:** Results obtained from this study will complement chemical and cultural methods to control weeds in onion. This will be integrated with methods developed in Activity 1.1.

**h.** **Progress to date**: Edwin Martin, who is studying for his M.S. degree in Weed Science at UPLB completed a three-month specialized training course with Dr. L.T. Kok at Virginia Tech to study the methods and techniques in biological control of weeds. In preparation for this study, Edwin Martin worked on two research studies; 1) effects of weevil infestation on the overall growth and reproduction of thistle seeds and 2) effect of insects attacking vegetable crops, brocolli and the associated biocontrol agents. The methods involved in the two studies will prepare him in the conduct of his thesis research on biological control of *T. portulacastrum* using *S. recurvalis* as biocontrol agent.

**i.** **Projected output:** 1) Protocol for mass rearing of *S. recurvalis* and other natural enemies; 2) Reduced populations of *T. portulacastrum* in onion fields.

**j.** **Projected impact**: Reduced production costs due to handweeding and herbicides.

**k.** **Projected start:** April 1, 2002

**l.** **Projected completion:** March 31, 2003

**m.** **Projected person-months of scientist time per year**: 5-6

**n.** **Budget:** PhilRice – $ 6,440; VT –$ 1,270; Penn State – $ 3,246

### II.2. Management Of Anthracnose and Bacterial Spot Diseases of Pepper (*Capsicum* sp.)

**a.** **Scientists**: E.B. Gergon– PhilRice; N.L. Opina - UPLB; S.A. Miller – Ohio State

**b.** **Status**: Continuing activity

**c.** **Objectives:** 1) Identify species of *Colletotrichum* and races of *Xanthomonas* cp *vesicatoria* affecting pepper; 2) Classify bacterial isolates into races; 3) Identify commercial and farmer's varieties of hot and sweet pepper which are resistant to different species/races of *Colletotricum* spp. and *X.* cp. V*esicatoria;* 4) Evaluate commercially available fungicides for the control of anthracnose disease of pepper under field conditions.

**d.** **Hypotheses: (**1) There are different species of *Colletotrichum* and races of *Xanthomonas* cp *vesicatoria* affecting pepper; (2) Varieties resistant to anthracnose and bacterial spot are available; (3) Currently available methods and rates of application of commercially available fungicides are effective against pathogens causing anthracnose disease of pepper.

**e.** **Description of research activity**:

*Identification of Colletotrichum species and races of Xanthomonas cp vesicatoria affecting pepper.* Infected fruits or seeds of pepper will be collected from farmer's fields. Isolation, identification, and pathogenicity tests will be conducted on the causal pathogen. Pure cultures of *Colletotricum* will be prepared on PDA medium and growth and sporulation of different isolates will be compared. Different hosts of *X.* cp *vesicatoria* will be inoculated.

*Screening of commercial and farmer's varieties for resistance to anthracnose and bacterial spot.* Seeds of pepper from different sources will be collected. Pure isolates of *Colletotricum* spp. and *X.* cp. *Vesicatoria* will be prepared. Different varieties will be inoculated with *Colletotricum* spp. and different races of *X.* cp. v*esicatoria.*

*Field evaluation of different fungicides against anthracnose disease of pepper.* Pepper will be grown from infected seeds. Pepper grown from infected seeds will be sprayed when 50% of the plants have flowered. The number of infected and uninfected fruits will be recorded.

*Screening of different fungicides for seed treatment against anthracnose disease of pepper.* Infected seeds of pepper will be given different treatments. After treatment, seeds will be air-dried, and sown in sterile soil. Seedlings will be transplanted into farmer's field in RCBD layout with 4 -5 replications. Field monitoring will be conducted at weekly intervals for disease incidence and severity. Yield of pepper will be determined at harvest. Fruits will be sorted accordingly.

The host country researchers, E. Gergon and N. Opina, will undergo a short-term training for use of molecular tools in detecting bacteria and fungi in plant samples, bacterial and fungal identification, development of markers and identification of races in Dr. Sally Miller's laboratory at Ohio State.

f. **Justification**: Pepper is becoming an economically important vegetable in the Philippines. Bacterial spot caused by *Xanthomonas campestris* pv. *vesicatoria* is an important disease of pepper. There is no available chemical means of control for this disease except by host resistance. Since there are possibly different races of the pathogen, available varieties should be tested against these different races. Anthracnose disease is also becoming serious in pepper and widespread during the last cropping season. Both diseases are seedborne and can be carried from one season to another by the use of infected seeds. Several chemicals have been reported effective as seed treatment and as spray against these diseases, however, new chemicals that are less toxic have come out in the market and it would be important to test the new chemicals against these pathogens.

g. **Relationship to other CRSP activities at the site:** This activity should provide information on management tactic recommended for a specific pathogen.

h. **Progress to date:** The pathogens causing bacterial spot and anthracnose diseases have been isolated, tested for pathogenicity, and their identifications confirmed. Initial testing of different chemicals has been conducted and promising ones have been identified.

i. **Projected output:** Identification of a method of managing bacterial spot and anthracnose diseases of pepper

j. **Projected impact:** Reduction of seed-borne diseases of pepper with lesser chemical inputs.

k. **Projected start**: October 2002

l. **Projected completion**: September 2003

m. **Projected person-months of scientist time per year:** 6

n. **Budget**: PhilRice – $ 2,750; OSU – $ 5,544

## SOCIO-ECONOMIC IMPACT ANALYSIS STUDIES

### III.1. Social Impact Assessment of IPM CRSP Technologies

a. **Scientists:** S.M. Roguel - CLSU, R.B. Malasa - PhilRice, C. Harris - Virginia Tech; C. Sachs - Penn State

b. **Status:** Continuing activity

c. **Overall objectives: (**1) Determine the communities' perception on the use/adoption of IPM CRSP technology, (2) Identify and assess the possible social effects and impacts of IPM CRSP technologies on the community, and (3) Identify and suggest possible mitigation and enhancement measures of the impacts of IPM CRSP technologies. **Year 10 objectives**: To conduct social impact assessment studies on management of eggplant fruit and shoot borer and on biological control of root knot nematode in onion.

d. **Hypothesis:** The introduced IPM CRSP technologies will be socially profitable to the farmers.

e. **Description of research activity:** The study will use a combination of research tools. The primary respondents will be men and women farmers in whose fields the IPM CRSP technology has been conducted and neighboring farmers of both sexes. Structured interviews will be used to gather basic socio-economic and demographic profiles of the respondents. Focus group discussions and key informant interviews will also be used for data gathering. An assessment will be made of the anticipated social environment, with and without the proposed technology. This process involves determining (1) what is likely to happen to the social environment, (2) who is likely to be affected by any change(s), (3) how they may be affected, and (4) how long these effects are likely to last. Suggestions will be made to mitigate negative impacts of the technologies or to increase positive impacts.

f. **Justification:** The impact of technology is always assumed as beneficial if its effects on a community are economically positive. However, experience has shown that this is not necessarily the case. The effect of the technology on the community and people should also be seriously considered. This assessment will also provide timely feedback from farmers to researchers on how research and extension activities can be better designed to make technologies more adaptable to a given community.

g. **Relationship to other CRSP activities at the site:** This study will complement the economic and environmental impact assessment studies on promising IPM CRSP technologies.

h. **Progress to date:** Results of SIA studies conducted in Year 9 showed that stale seedbed technique is socially acceptable and beneficial to farmers. Rice hull burning has both positive and negative effects. Recommendations to mitigate the negative effects were made.

i. **Projected output: (**1) Identification of negative or positive effects of IPM CRSP technologies, with report on the social impacts and implications of the IPM technologies, (2) Papers on social impacts of the IPM CRSP technologies; (3) Identification of factors affecting technology adoption.

j. **Projected impact:** Widespread adoption of IPM CRSP technologies.

k. **Projected start:** October 2002

l. **Projected completion:** September 2003

**m.** **Projected person-months of scientist time per year:** 3

**n.** **Budget:** PhilRice – $ 2,200; Penn State – $ 30,525

## III.2. Economic Impacts of IPM Practices in Rice-Vegetable Systems

**a.** **Scientists:** S. Francisco – PhilRice; G. Norton – Virginia Tech

**b.** **Status:** Continuing activity

**c.** **Overall objectives:** (1) To evaluate and project the impact of IPM practices generated from multidisciplinary field experiments on household income and on society as a whole once adopted; (2) Project the economic impacts of biotechnology research on rice and vegetables. **Year 10 objective:** To conduct economic impact assessment studies on integrated weed management, onion storage method, eggplant grafting and other promising technologies developed in Year 9.

**d.** **Hypotheses:** (1) Each of the tested IPM practices will be profitable to farmers; (2) Each of the tested practices will generate net economic benefit to society as a whole when adopted; (3) Each of the tested IPM practices will have significant economic benefits for small farmers and consumers, and will have significantly positive environmental effects through reduction in pesticide use.

**e.** **Description of research activity**: Budgets will be developed for current crop practices and for each of the alternative pest management practices being evaluated in field experiments. Information generated on cost changes per unit of output will be combined with projections on the level and timing of adoption of IPM practices and economic surplus analysis then used to project aggregate societal benefits.

**f.** **Justification:** Knowledge of farm-level profitability of IPM practices per hectare and per farm-household is essential in designing pest management recommendations. Knowledge of aggregate social benefits helps research directors and others assess the merits of specific IPM activities. If a specific IPM activity reduces pesticide use and has significant environmental benefits and is therefore socially profitable but is not privately profitable, this information can be useful to policy makers in designing tax, subsidy, or regulatory programs to encourage adoption of IPM practices.

**g.** **Relationship to other CRSP activities at the site:** Other activities are underway to assess social and gender impacts of pest management technologies. This activity complements the other activities as the estimated economic impacts can be distributed by family members and gender. The economic impact assessment provides feedback on the profitability being tested in the other workplan activities.

**h.** **Progress to date:** Report on economic impacts of IPM practices has been prepared and presented to the IPM CRSP group. The report discusses which of the developed technologies has a yield enhancing and cost reducing effect over the current farmer's practice. A MS thesis student studied the effects of rice biotechnologies and has completed his work and presented the results last January 2002.

i. **Projected output:** (1) Identification of IPM technologies that provide economic benefits; (2) Identification of factors affecting technology adoption.

j. **Projected impact:** The results should influence decisions on: (1) which technologies to promote in training programs, (2) which IPM alternatives might justify further research, (3) on pest management policies and regulations and 4) information to the general public on the benefits and costs of biotechnologies.

k. **Projected start:** October 1, 2002

l. **Projected completion:** September 30, 2003

m. **Projected person-months of scientist time per year:** 2

n. **Budget:** PhilRice – $ 6,050; VT – $3,175

### III.3. Comparative Economic Analysis of Effectiveness of Different Approaches in Technology Delivery

a. **Scientists:** S.R. Francisco, B. Catudan – PhilRice; G. Norton – Virginia Tech

b. **Status:** New activity

c. **Overall objectives: (**1) To evaluate cost effectiveness of different modes of IPM CRSP technology delivery systems; (2) Determine factors that favor/prevent the effectiveness of the modes of delivery.

d. **Hypotheses:** (1) Effectiveness of delivery depends on the nature of technology; (2) Easily comprehensible technologies and those that do not require long demonstration period are easily adopted while more complex technologies require longer demonstration and educational campaign before they get adopted.

e. **Description of research activity:** The different modes of technology dissemination process will be evaluated based on the ease of dissemination and cost effectiveness. Information generated on the different modes of delivery in terms of resources use and rate of adoption will be used to determine the cost effectiveness of the system.

f. **Justification:** IPM CRSP has identified technologies that are cost-saving and yield-increasing. Awareness regarding these technology or information, coupled with their economic benefits are the driving forces that lead to their adoption. However, depending on the nature of technology, increasing awareness of the target beneficiaries can be a constraint in the dispersion of the technology due to various reasons. Among these are the inadequacy of resources for widespread dispersal of the information and inefficiency of the channels of information. This study will identify which among the modes of delivery can reach as many target clientele and at the same time are cost effective. Information that can be generated from this undertaking will be helpful in designing cost-effective technology transfer mechanism that will ensure high rate of adoption.

**g.** **Relationship to other CRSP activities at the site:** IPM CRSP has identified/developed/ improved technologies which are superior to existing farmers' practice which are ready for transfer to target clientele, the farmers. This activity supplements the other activities at the site by identifying technology-specific methods of technology transfer that are cost-effective for widespread and effective delivery of these technologies.

**h.** **Progress to date:** Not applicable (new activity)

**i.** **Projected output:** Cost-effective technology specific methods of technology delivery systems.

**j.** **Projected impact: (**1) Increased awareness on IPM in onion and eggplant in Nueva Ecija; (2) Reduced pesticide use and increased vegetable production, particularly onion and eggplant.

**k.** **Projected start:** October 1, 2002

**l.** **Projected completion:** September 30, 2003

**m.** **Projected person-months of scientist time per year:** 3

**n.** **Budget:** PhilRice – $ 1,320; VT – $ 27,590

### III.4. IPM Technology Transfer and Feedback

**a.** **Scientists:** S.M. Roguel, R.T. Alberto – CLSU, IPM CRSP and Technology Promotion Staff – Philrice, M.C. Lit, N.L. Opina – UPLB, E.G. Rajotte – Penn State, S.S. Miller – Ohio State, G.W. Norton – Virginia Tech

**b.** **Status:** Continuing activity

**c.** **Overall objective:** To conduct activities to transfer IPM technologies and disseminate information on IPM on a wide scale to Filipino farmers. **Year 10 objectives:**
1) Conduct training courses on vegetable IPM for agricultural technologists and farmers;
2) Disseminate IPM CRSP technologies utilizing various communication media such as print, radio, TV, videos and other channels;
3) Establish network with international agencies, national and local government organizations (GOs), non-government organizations (NGOs), professional associations, and other stakeholders on research and delivery sytems of IPM;

4) Assess the impact of different technology transfer strategies like training courses, village level integration studies; publications, symposia, and similar strategies.

**d. Hypothesis:** No research hypothesis.

**e. Description of activity:** A multiprong, multilevel approach will be conducted to intensify dissemination of IPM technologies addressing different audiences. Some of the activities that will be conducted are: 1) Involvement of IPM CRSP scientists as resource persons in training courses organized by PhilRice and other agencies; 2) Conduct of training course on rice-vegetable production for agricultural scientists and farmer leaders at PhilRice and on-site using the Farmers' Field School approach; 3) Production of IPM CRSP training materials such as technology guides, manuals, leaflets, posters, videos, and other print and interactive media; 4) Holding of a high level conference of heads on international (e.g. IRRI, FAO, IIRR) and national agencies (e.g. ATI, BPI, NCPC, SUCs) involved in IPM as well as national media organizations (e.g. KBP, PIA) to share their experiences and to get commitment for IPM advocacy; 5) Conduct of village level integration project in collaboration with PhilRice Rice-Based Farming Systems Program; 6) Observance of field days and farmer's meetings in IPM CRSP experimental sites; 7) Holding of slogan contests, poster making and jingles on IPM among students and out-of-school youth; 8) Creating public awareness on IPM through use of billboards, mass communication media, and other promotion strategies; 9) Conducting participatory research on IPM technologies with farmers; 10) Developing a training couse on IPM on-line; 11) Developing information materials on IPM for childern in cooperation with Department of Education.

To assess impact of these technology transfer strategies, the following will be done: 1) Pre-tests or post-tests will be conducted to assess knowledge gained, retained or diffused among training participants to assess impact of training courses. To assess impact of the other technology transfer strategies, surveys will be conduted to gather information on the amount of pesticides used, crop yields and net incomes and will be compared before and after use of the IPM CRSP technology. A survey of farmers in barangays where IPM techno demo farms and village level integration trials were conducted will be done to assess if other farmers in the area are adapting or "copying" the IPM CRSP technology. Information of volume of sales of pesticides will also be gathered.

**f. Justification:** This activity will ensure the spread of results of IPM CRSP research farmers and other stakeholders and will provide feedback to the scientists of this project. It will increase awareness among farmers and the general public about the project and the need to practice IPM on vegetables using more sustainable and environment friendly farming practices. Moreover, reduction of pesticide use through IPM should increase farmers' income and safeguard their health. Assessing the impact of technology transfer strategies will enable researchers to compare and determine fast, efficient and cost-effective methods of delivery systems to transfer technology.

g. **Relationship to other CRSP activities at the site:** The technology transfer collaboration will draw upon IPM CRSP research results and technologies developed during the past 9 years. It will be done in collaboration with the other units in Philrice, particularly, the Technology Promotion and Rice-Based Farming Systems Programs and with other agencies involved in IPM advocacy. The activities to be conducted will complete farmers' training which started with rice and will reinforce PhilRice role in the national IPM training of farmers in rice-vegetable systems. Information from the studies on impact assessment of different technology transfer strategies will complement those in Activities III.1, III.2 and III.3.

h. **Progress to date: 1) Training courses:** Short-term and season-long training courses for farmers on : a) IPM in onion and eggplant; b) IPM in rice-vegetable cropping systems; c) mass production of NPV were conducted at PhilRice from 1999 to date; IPM CRSP scientists have served as resource persons in several training courses conducted at PhilRice and other agencies; **2) Village level integration project:** On-farm demo plots comparing IPM CRSP technologies and farmers' practice have been established in farmers' fields in San Jose and Bongabon, Nueva Ecija in 2000 and 2001 onion cropping seasons; **3) Training materials:** Six sets of materials for technology guides have been submitted to Development Communications Division for publication. A training manual on IPM in vegetables grown after rice in rice-based cropping systems is currently being prepared; **4) Publications and paper presentations:** Sixty seven research papers were presented by IPM CRSP scientists at local and international conferences, and 38 papers have been published in Philippine and international journals. **Impact assessment of technology transfer strategies:** No studies have yet been conducted, will be started in year 10.

i. **Projected output:** 1) Training manual on IPM in vegetables; 2) IPM technology guides for onion, eggplant, and other vegetables; 3) Technical papers and popular articles on IPM methods and practices; 4) Videos, posters, jingles on IPM; 5) IPM advocacy network; 6) Information on cost-effective methods of technology transfer.

j. **Projected impact:** 1) Increased awareness of IPM in vegetables; 2) Increased application of IPM principles and practices; 3) Reduced pesticide use and increased vegetable production particularly in onion and eggplant; 4) Higher income for farmers.

k. **Projected start:** October 2002

l. **Projected completion:** September 2003

m. **Projected person-months of scientist time per year:** 6

n. **Budget:** IPM CRSP Funds, PhilRice Funds

**INTEGRATED PEST MANAGEMENT – COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), ASIA SITE (Philippines)**

(September 30, 2002 – September 29, 2003)

| ACTIVITY | SCIENTISTS | BUDGET ($) |
|---|---|---|
| **FIELD EXPERIMENTS (On-Farm and PhilRice CES)** | | (PhilRice) |
| I.1. Integrated Weed Management Strategies in Rice-Onion Systems | A.M. Baltazar – UPLB; J.M. Ramos, E.C. Martin, M.C. Casimero – PhilRice; A.M. Mortimer – IRRI; S.K. De Datta - Virginia Tech. | 6,050 |
| I.2. Seasonal Abundance, Incidence of Larval Parasitism, and Effect of Trap Color on Attraction of Onion Leafminer, *Liriomyza trifolii* (Burgess) Adults. | G.S. Arida, E.R. Tiongco, B.S. Punzal, C.C. Ravina-PhilRice, E.G. Rajotte - Penn State | 5,610 |
| I.3. Influence of Host Plant Resistance and Grafting on the Incidence of Bacterial Wilt in Eggplant | N.L. Opina - UPLB, R.T. Alberto – CLSU, S.E Santiago - PhilRice, R.M Gapasin – LSU, S.A. Miller - Ohio State | 0<br>(to be funded by P.L 480) |
| I.4. Combined Resistance of Eggplant, *Solanum melongena* L., to the Leafhopper *Amrasca biguttula* (Ishida) and Eggplant Borer, *Leucinodes orbonalis* Guenee | M. T. Caasi-Lit, R.G. Maghirang, M.A.A. Capricho – UPLB; N.S. Talekar – AVRDC; E.G. Rajotte – Penn State | 0<br>(to be funded by P.L 480) |
| I.5. Management of the Eggplant Fruit and Shoot Borer *Leucinodes orbonalis* (Guenee): Evaluation of Farmers Indigenous Practices | G.S. Arida, C.C. Ravina, B.S. Punzal – PhilRice; E.G. Rajotte –Penn State | 3,260 |
| I.6. Management of Anthracnose (*Colletotrichum gloeosporioides*), A Disease of Increasing Importance in Onion | R.T. Alberto – CLSU; M.S.V. Duca – PhilRice, S.A. Miller – Ohio State | 1,985 |

| | | |
|---|---|---|
| I.7. Management of *Spodoptera litura* (F.) and *S. exigua* (Hubner) by Mass Trapping and Timing of Interventions in Farmers' Fields | G.S. Arida, B.S. Punzal, C.C. Ravina - PhilRice, N.S. Talekar – AVRDC; E.G. Rajotte - Penn State | 1,760 |
| I.8. Effect of Level of Defoliation at Different Crop Ages on Yield of Onion | G.S. Arida, C.C. Ravina, B.S. Punzal - PhilRice; E.G. Rajotte - Penn State | 5,060 |
| I.9. Biological Control of Soil-borne Pathogens Using *Trichoderma* sp. in Rice-Vegetable Systems | R. M. Gapasin – LSU; S.A. Miller – Ohio State; R.T. Alberto - CLSU | 5,450 |
| I.10. Biological Control Of *Meloidogyne graminicola* and Other Soil Borne Pathogens in Rice-Vegetable Systems Using Specific Biological Control Agents | E.B. Gergon– PhilRice; R.M. Gapasin - LSU; M. Brown – UPLB; S.A. Miller – Ohio State | 7,260 |
| I.11. Effect of Nitrogen on Bulb Rot Incidence in Onion During Storage | D.T. Eligio, R.T. Alberto – CLSU, S.A. Miller – Ohio State | 0 |
| **LABORATORY, GREENHOUSE, AND MICROPLOT EXPERIMENTS.** | | |
| II.1. Biology, Life Cycle, and Mass Rearing of *Spoladea recurvalis* as Biocontrol Agent Against *Trianthema portulacastrum* | A. M. Baltazar – UPLB; E. C. Martin, M. C. Casimero, J. M. Ramos – PhilRice; S. K. De Datta, L. T. Kok – Virginia Tech; E.G. Rajotte – Penn State | 7,040 (to be funded by P.L 480) |
| II.2. Management Of Anthracnose and Bacterial Spot Diseases of Pepper (*Capsicum* sp.) | E.B. Gergon– PhilRice; N.L. Opina - UPLB; S.A. Miller – Ohio State | 0 (to be funded by P.L 480) |

| | | |
|---|---|---|
| **SOCIOECONOMIC ANALYSIS** | | |
| III.1. Social Impact Assessment of IPM CRSP Technologies | S.M. Roguel - CLSU, R.B. Malasa - PhilRice, C. Harris - Virginia Tech; C. Sachs - Penn State | 2,200 |
| III.2. Economic Impacts of IPM Practices in Rice-Vegetable Systems | S. Francisco – PhilRice; G. Norton – Virginia Tech | 6,050 |
| III.3. Comparative Economic Analysis of Effectiveness of Different Approaches in Technology Delivery | S.R. Francisco, B. Catudan – PhilRice; G. Norton – Virginia Tech | 1,320 |
| III.4. IPM Technology Transfer and Feedback | S.M. Roguel, R.T. Alberto – CLSU, IPM CRSP and Technology Promotion Staff - PhilRice, M.C. Lit, N.L. Opina – UPLB, E. Rajotte – Penn State, S.A. Miller – Ohio State, G. Norton – Virginia Tech | IPM CRSP Funds, PhilRice Funds |

# Year 10 Work plan for the Asian Site in Bangladesh

In year 10, the IPM CRSP will begin its fifth year of research in Bangladesh. Activities focus on rice/vegetable systems, with key crops including eggplant, cabbage, gourds, tomatoes, country bean and okra. The PIPM approach is being followed in which pest management problems and constraints are being diagnosed through crop/pest monitoring, and follow-up participatory appraisal and focus group activities are being undertaken that focus specifically on adoption issues, including gender. Multi-disciplinary on-farm pest management experiments are being conducted in Kashimpur, complemented by varietal screening, laboratory, greenhouse, and micro-plot experiments on station near Joydepur, and by village level testing and demonstrations in other major vegetable areas in the country. Socioeconomic analyses address three primary issues: impact assessment, adoption, and market analysis. Linkages have been made with the local extension service in Bangladesh, CARE-Bangladesh, Mennonite Central Committee (MCC) and with the Helen Keller Institute, to facilitate farmer training with lessons learned on the CRSP.

Research activities are planned and conducted in a multidisciplinary fashion. Bangladesh and U.S. scientists review progress and plan future activities in joint meetings with all disciplines contributing to the discussion. Biological scientists assist the social scientists by collecting cost and return data that is used in impact assessment. The site coordinator and his staff help coordinate the day-to-day research activities. They are housed with most of the scientists at the Bangladesh Agricultural Research Institute (BARI), the primary agricultural research institute in the country. They coordinate with scientists at The Bangladesh Rice Research Institute (BRRI), CARE-Bangladesh, and with the Bangabandhu Shaikh Mujibur Rahman Agricultural University (BSMRAU) near BARI for student training. International and U.S. institutions contributing to the IPM CRSP program in Bangladesh include AVRDC, IRRI, the National Crop Protection Center of the Philippines, Purdue University, Penn State, Ohio State, and Virginia Tech.

IPM CRSP research activities in Bangladesh will be carried out in year ten under four major thematic areas: (1) crop/pest monitoring, (2) multidisciplinary on-farm pest management experiments, (3) multidisciplinary laboratory, greenhouse, and microplot experiments, and (4) socioeconomic analyses.

## I. Baseline Survey and Crop/Pest Monitoring

### I.1. Survey of Infestation Levels of White Fly, *Bemisia tabaci*, on Different Vegetable Crops

a. **Scientists:** S.N. Alam, M. Khorsheduzzaman- BARI; A, N. M. R. Karim, H. S. Jasmine-IPM CRSP; E. Rajotte – Penn State; Greg Luther- Virginia Tech

b. **Status:** New

c. **Objectives (overall and current year):** (1) To determine the incidence pattern and infestation levels of white fly on different vegetable crops; (2) To identify the damage variability and most susceptible vegetable crop(s); and (3) To identify appropriate researchable issues for developing IPM practices in vegetables.

d. **Hypotheses:** Recently, white fly, *B*. tabaci, has appeared to be a serious damaging pest in a number of major vegetable crops and farmers apply insecticide indiscriminately without knowing the pest, their infestation levels or damage potential. Knowledge of their incidence patterns and their damage intensity, and identification of susceptible vegetables will enable to determine the appropriate researchable issues for developing IPM practices for the vegetables.

e. **Description of research activity:** Trapping of white fly will be done by setting up yellow sticky traps in the major vegetable crop fields (eggplant, tomato, beans, okra, etc.) at BARI farm and Kashimpur (Gazipur), Jessore and Comilla. A locally prepared sticky gum will be used for the traps. The trapped white flies will be sorted out to identify the species. Records will be taken on infestation and damage intensities to determine the susceptibility of the infested crops.

f. **Justification:** The white fly, *B. tabaci*, is becoming an increasingly damaging pest on different vegetable crops due to indiscriminate use of pesticides by the farmers. The white fly has a wide host range, but its infestation rates in different crops are not known. Appropriate pest management measures can be developed based on the identification of susceptibility status of the vegetable crops. The highly susceptible crop(s) can also be used as a trap crop(s).

g. **Relationship to other research activities at the site:** The survey activity will be useful for developing proper management practices of white flies in different vegetable crops. It will also help other research groups to identify appropriate researchable issues for the development of IPM technologies.

h. **Progress to date:** New

i. **Projected outputs:** Improved knowledge of (1) white fly species composition, their incidence and infestation patterns, and damage potential; and (2) vegetable crop(s) susceptible to white fly and ways to find out the appropriate control measures.

j. **Projected impacts: (**1) Better knowledge of white fly incidence, their infestation patterns and damage characteristics; (2) Identified appropriate research activities for developing appropriate measures for white fly control.

k. **Projected start:** October 2002

l. **Projected completion:** September 2003

m. **Projected person-months of scientists time per year:** 8 person-months

n. **Budget:** BARI – $ 1,760; Penn State – $64,827; AVRDC – $5,005

## I.2. Survey and Population Dynamics of Bean Pod Borer (*Maruca testulalis*), Whitefly and Aphids and their Natural Enemies on Country Bean (*Lablab purpureus*)

a. **Scientists:** M. Mozammel Hoque, S.M. Monowar Hossain, Salim Reza Mollik, M. Nazim Uddin, S. N. Alam, M. Khorsheduzzaman – BARI; Mahbubur Rahman – IPM CRSP; Z. Alam – BSMRAU; E. Rajotte – Penn State; G. Luther – Virginia Tech

b. **Status:** New

c. **Objectives:** (1) To determine abundance, incidence patterns, and seasonality of the pests and their natural enemies, and assess the damages inflicted to the crops in various parts of Bangladesh; (2) To examine the population dynamics of pests of country bean, especially pod borer (*Maruca testulalis*), whitefly and aphids (*Aphis craccivora*) and their natural enemies. **Objectives in 2002-2003:** To obtain baseline information on population dynamics of these pests and natural enemies. (3) To find out appropriate researchable issues to develop IPM practices for effective control of the pest. **Objectives in 2002-2003:** To complete a year-round survey and identify the above.

d. **Hypotheses:** Populations of pod borer and its natural enemies fluctuate according to season, climate, agroecosystems, and crop varieties. In addition, populations of various other pests and natural enemies vary in different seasons, climate, crop combinations and country bean varieties. The information will greatly help to develop effective control measures based on IPM approach in order to eliminate or substantially reduce the current farmers' practice of indiscriminate pesticide use on country beans.

e. **Description of research activity:** A year-round survey will be conducted on country bean (*Lablab purpureus*) and other available legume species to determine the population dynamics of pod borer and its natural enemies. This will be conducted in various parts of Bangladesh where country bean is intensively cultivated.

Counts will be made to determine numbers of pod borer on various varieties of country bean. Observations will be made to determine which predator species are preying upon the pod borer. Pod borer larvae will be collected and reared for parasitoid emergence and parasitism rates will be determined. Farmers' current practice to control the pest will also be recorded. A baseline investigation of population dynamics of pod borer, whitefly, aphids and other pests, and their natural enemies will be conducted on country beans throughout year by growing two country bean varieties (BARI Sheem-1 and a Farmer variety) at the BARI farm and in farmer fields in Jessore. Additional varieties may be planted if available.

Numbers of whiteflies, aphids, pod borer, coccinellids, spiders and other natural enemies will be monitored and recorded once per week. Trapping of whiteflies may be conducted with yellow or blue sticky traps. Special attention will be given to the parts of the plant (flowers, pods, shoots, etc.) that are attacked by pod borer at various plant growth phases. The possibility of using mechanical removal of infested flowers/pods/shoots as a pod borer IPM method will be investigated as a preliminary tactic. Yield and size of beans will be recorded from all plots.

**f.** **Justification:** *Maruca* is a serious pest on a variety of legumes, including country bean in Asia. Country bean is one of the most popular vegetables widely grown in home gardens and on a commercial scale in Bangladesh. Based on findings, an integrated package for insect control on country bean may be developed. Information may be useful for IPM on other leguminous crops, which also share the same pests. Country bean is a major and popular vegetable widely grown in Bangladesh. It is grown in home gardens as well as on a commercial scale. Pod borers, white fly and aphids are the serious pests on country beans, reducing both yield and quality. Farmers use insecticide indiscriminately without much success. Based on findings, an integrated package for the control of bean pests may be developed. Information will also be useful for IPM on other leguminous crops, which also share the same pests.

**g.** **Relationship to other research activities at the site:** This will help in the process of putting together an IPM package for country bean. Information on natural enemies may be shared with other activities. Information on pest control and natural enemies of these insects may be shared with other activities.

**h.** **Progress to date:** New activity.

**i.** **Projected outputs:** Improved knowledge on pod borer and their natural enemies; and development of an IPM package for pod borer control. (1) Improved knowledge of population dynamics of pests and natural enemies on country bean; and (2) An effective IPM package developed for the control of pests of country beans.

**j.** **Projected impacts:** Use of IPM methods will substantially reduce pesticide use, which in turn will have a favorable impact on the environment and human health. IPM methods will also improve the economic situation of farmers.

**k.** **Projected start:** August 2002

**l.** **Projected completion:** September 2004

**m.** **Projected person-months of scientists time per year:** person-months

**n.** **Budget:** BARI – $ 5,500

## II. Multidisciplinary On-farm Pest Management Experiments

### II.1a. Varietal Screening of Eggplant for Resistance to Bacterial Wilt (BW), Fruit and Shoot Borer (FSB) , Leafhopper (jassids) and Root-Knot Nematode (RKN) and of Tomato for Resistance to BW, Virus Disease and RKN

a. **Scientists:** M.A. Rashid, Shahabuddin Ahmed, M.A. Rahman, Motiar Rahman, M. A. Gaffar, S.N. Alam, M.H. Rashid, M.I. Faruk – BARI; H.S. Jasmine, Nazneen A. Sultana, Baha Uddin Ahmed – IPM CRSP; L. Black, J.F. Wang, N.S. Talekar – AVRDC; G. Luther – Virginia Tech

b. **Status:** Ongoing

c. **Objectives:** To (1) confirm the usefulness of previously reported bacterial wilt (BW) resistant eggplant and tomato cultivars and potential focus on *Solanum* rootstock in Bangladesh, (2) search for new sources of wilt resistance; (3) confirm previously reported FSB resistant sources and to identify new sources of resistance in eggplant; (4) confirm root-knot nematode resistance in eggplant and tomato cultivars previously identified at BARI; (5) confirm previously reported TYLCV resistant sources and to identify new sources of resistance in tomato; and (6) evaluate commonly used eggplant and tomato cultivars in Bangladesh for their reaction to RKNs. **Objectives in 2002-2003: (**1) To confirm the resistance of the eggplant varieties selected in 2001-2002 against FSB, BW and RKN; and (2) To test new tomato germplasm against BW, RKN and Tomato Yellow Leaf Curl Virus (TYLCV), and confirm the resistance of the varieties selected in 2001-2002.

d. **Hypotheses: (**1) Based on previous work at BARI and AVRDC, BW resistant eggplant and tomato cultivars exist. Further selection in Bangladesh will lead to identification of cultivars that can be utilized by Bangladeshi farmers. Grafting with susceptible eggplant and tomato varieties onto resistant *Solanum sps.* rootstocks is effective in controlling bacterial wilt; (2) Natural FSB resistance that occurs in *Solanum sps.* can be introgressed through breeding into eggplant cultivars; (3) Sources of TYLCV resistance are present in currently available cultivars that may be useful to Bangladeshi farmers; and (4) Sources of RKN resistance are present in currently available cultivars that may be useful for on-farm use.

e. **Description of research activity:** Initial work will be done at HRC, BARI laboratory and infested nurseries. For eggplant, the preliminarily selected entries and those showing variable reactions will be evaluated in 2002-2003. Approximately 100 cultivars of eggplant and 50 cultivars/lines as well as tolerant lines of tomato that were identified previously at BARI will be evaluated for their BW reactions. BW inoculum level will be enhanced to $10^8$ cfu/gm soil by incorporating highly BW infected eggplants in the nurseries prior to transplanting. Thirty-day old seedlings of eggplant and tomato will be uprooted, roots trimmed and transplanted into the infested nursery using 6x6 inch spacing. Plants will be observed closely. Plant mortality will be recorded at 3-day intervals. In years 4-5, the resistant eggplant and tomato varieties developed at BARI will be evaluated in farmer fields.

Initial study for FSB will be conducted at the BARI field to evaluate the resistance sources of major cultivated eggplant varieties and available resistant wild species. Seeds will be sown in September 2002 and transplanted in October 2002. About 100 *Solanum* accessions will be evaluated for their resistance to the natural population of FSB without application of insecticides. A replicated trial with 3 replications of 5 plants each will be arranged in RCBD using a spacing of 70x70 cm. Weekly observations will be made on fruits and shoots. Wilted shoots will be counted along with the total number of shoots per plant. Along with this, mass culture of adults and 1$^{st}$ instar larvae will be done from the infested fruits and will be released in cages having twigs of different eggplant lines in the screenhouse and in the field under confinement. Observations will be taken on the difference on egg laying and larval entry in different lines.

The initial study of TYLCV will be conducted in screen house at HRC, BARI to evaluate the reported resistance sources of major cultivated varieties. Seeds will be grown in 40cm x 30cm x 8cm tin trays and the seedlings at the age of 21 days will be infested with viruliferous whiteflies for TYLCV infection. Weekly observation will be made on TYLCV infection. Infected seedlings will be counted and discarded, and disease free seedlings will be transplanted in the field for seed multiplication. Data will be recorded after 2 weeks and 8 weeks of the release of viruliferous insects.

Initial study of RKN will be made at BARI in infested nurseries. Approximately 80 cultivars of eggplant, including those cultivars which have previously shown resistance and 50 cultivars of tomato, including 2 cultivars that previously showed moderate resistance will be sown directly in the infested nursery and uprooted 60 days later and examined for severity of galling. Galling will be scored on a scale of 1-10.

**f.** **Justification:** Bacterial wilt (*Ralstonia solanacearum*) is a devastating disease in eggplant and tomato in Bangladesh. No practical chemical control or cultural practices have been developed for successful control of this disease. Also resistance is said to be site specific. Therefore, the BW resistant cultivars from other locations must be tested for usefulness in Bangladesh.

Eggplant fruit and shoot borer is a severe pest throughout Asia. There is no resistant variety available. For controlling this pest farmers are using insecticides indiscriminately, which has potential harmful effects to the consumers and the environment. Development of pest resistant varieties will minimize the risks of hazards.

TYLCV, which is transmitted by white fly (*Bemisia tabaci*), is one of the serious diseases of tomato in Bangladesh and the yield loss is as high as 100%. Selection of resistant variety is one of the cheap and effective methods to minimize the disease.
Nematode is a major problem of eggplant and tomato and there is no practical chemical control or cultural practices developed for its control. Development of resistant varieties is one option for minimizing losses due to this pest.

**g.** **Relationship to other research activities at the site:** Identification of resistant varieties and grafting technology will be utilized in farmer field studies in combination with other IPM strategies.

**h.** **Progress to date:** In 2001-2002 winter season, 47 germplasm lines of eggplant have been evaluated against bacterial wilt and RKN in sick-beds, and 50 germplasm lines, including a number of entries from AVRDC sources, have been tested at BARI farm under natural conditions against FSB, BW and jassids. Also 32 lines/varieties of tomato have been screened against BW. Several varieties/lines have been preliminarily selected in each case.

i. **Projected outputs:** (1) Confirmation of reported BW resistance sources under Bangladesh condition; (2) Identification of additional BW resistance sources; (3) Confirmation of reported FSB resistance sources under Bangladesh condition; (4) Identification of additional FSB resistance sources; (5) Confirmation of reported TYLCV resistance sources under Bangladesh condition; (6) Identification of additional TYLCV resistance sources; (7) Utilization of their resistance for development of varieties; and (8) Identification of RKN resistance sources.

j. **Projected impacts:** (1) Eggplant and tomato varieties/lines available to farmers will provide high levels of resistance to BW and reduce plant mortality in the hot wet season; (2) Improved yield; (3) Reduced losses caused by fruit and shoot borer; (4) Reduced use of insecticides; and (5) High level of resistance to RKN and reduced plant mortality.

k. **Projected start:** Eggplant-March 1999; Tomato- September 1999

l. **Projected completion:** September 2004

m. **Projected person-months of scientist time per year:** 6 person-months

o. **Budget:** BARI – $ 2,970; Ohio State – $27,405

**II.1b. Pilot Production of Grafted Eggplants at Two Intensive Growing Areas (Jessore and Sripur-Gazipur) and Training of Farmers and Nurserymen**

a. **Scientists:** M.A. Rashid, Shahabuddin Ahmed, Ataur Rahaman,– BARI; M. Rafiquddin – RARS, BARI (Jessore); Baha Uddin Ahmed– IPM CRSP; G. Luther – Virginia Tech; L. Black – AVRDC

b. **Status:** Ongoing

c. **Objectives (current and overall):** To (1) demonstrate and popularize eggplant grafting technology for BW control through pilot production; and (2) disseminate eggplant grafting technology through training of nurserymen and farmers.

d. **Hypotheses:** On-farm demonstration trials have proven that eggplant grafting on BW-resistant wild *Solanaum* rootstocks is highly effective for BW control and the farmers are keenly interested in adopting the technique. Training of nurserymen and growers and pilot production of grafted eggplants in intensive eggplant growing areas will help the diffusion and popularization of the technique.

e. **Description of research activity:** The activities will be carried out at Jessore and Sripur (Gazipur) starting from July 2002. Ten farmers and nurserymen, selected from each area, will be trained on grafting of cultivated eggplants on bacterial wilt (BW)-resistant wild *Solanum* rootstocks. For this purpose two low-cost grafting houses will be constructed in each area. Seeds of the wild *Solanum* species (*Solanum torvum* and *S. sisymbriifolium*) will be supplied by BARI. The local popular varieties will be used as scion. Grafting will be done by the trained nurserymen/growers under the supervision of BARI scientists. Five farmers will be selected from each area for pilot production of grafted eggplants and at least 500 plants will be established in each field starting in September 2002.

f. **Justification:** Bacterial wilt *(Ralstonia solanacearum*) is a devastating disease of eggplant in Bangladesh and no BW-resistant cultivated varieties is available. Since eggplant grafting on BW-resistant wild eggplant rootstocks has been proven highly effective for BW control in farmer fields, farmers are interested in adopting the technology. Training of nurserymen/growers and pilot production of grafted eggplants in intensive eggplant growing areas will help rapid dissemination of the technology.

g. **Relationship to other research activities at the site:** Grafting technology can be utilized by the farmers in controlling BW disease of eggplant in combination with other IPM practices.

h. **Progress to date:** On-farm demonstration trials on eggplant grafting, carried out in Jessore and at Sripur (Gazipur) in 2001-2002 winter season showed that grafting was highly successful in controlling BW disease, establishing more than 95% plant populations, producing high yield and bringing about high economic returns.

i. **Projected output(s):** Utilization of grafting by the farmers will help to obtain a better crop stand, higher yields and greater economic returns.

j. **Projected impacts: (**1) Reduced plant mortality; (2) Better crop stand; (3) Greater yield and economic return.

k. **Projected start:** July 2001

l. **Projected completion:** September 2003

m. **Projected person-months of scientists per year:** 12 person-months

n. **Budget:** BARI – $ 4,070; Ohio State – $2,520

**lI.1c. Development of Eggplant Hybrids Resistant to Bacterial Wilt (BW), Fruit and Shoot Borer (FSB) , and Root-Knot Nematode (RKN)**

**a.** **Scientists:** M.A. Rashid, Shahabuddin Ahmed, Ataur Rahman, – BARI; H. S. Jasmine, Nazneen A. Sultana– IPM CRSP; G. Luther – Virginia Tech; L. Black, J.F. Wang – AVRDC

**b.** **Status:** Ongoing with additional activity

**c.** **Objectives:** To develop high yielding hybrid varieties of eggplant resistant to bacterial wilt and FSB through hybridization. **Objectives in 2002-2003:** (1) To confirm the performance of the promising hybrids selected in 2001-2002; and (2) To include in the breeding program 17 new parents identified to be resistant to the pests and test their performance.

**d.** **Hypotheses:** BW and FSB tolerant eggplant cultivars exist and this character is transferable to cultivated varieties through hybridization.

**e.** **Description of research activity:** The lines identified as resistant/tolerant to BW, FSB and RKN will be used as donors and will be crossed with cultivated varieties having good horticultural traits. The crossing combinations will be placed under replicated trials to study heterosis and combining ability.

**f.** **Justification:** Eggplant varieties cultivated in Bangladesh are susceptible to BW, FSB and RKN. No cultivated varieties were found completely resistant to these pests. Therefore, development of $F_1$ varieties involving tolerant character will help to overcome the damage done by these pests to a considerable extent.

**g.** **Relationship to other research activities at the site:** Tolerant/ resistant $F_1$ varieties will be utilized by Bangladeshi farmers in combination with other IPM strategies.

**h.** **Progress to date:** Twenty one hybrids involving seven parents have been tested in the field and four hybrids have been selected having improved agronomic traits and pest resistance/tolerance to some extent.

**i.** **Projected outputs:** Development of BW, FSB and RKN resistant/tolerant high yielding eggplant varieties for on-farm use.

**j.** **Projected impacts:** (1) Reduced plant mortality due to BW, RKN and less infestation of FSB, (2) Higher yield and economic returns.

**k.** **Projected start:** September 2000

**l.** **Projected completion:** September 2003

**m.** **Projected person-months of scientist's time per year:** 6 person-months

**n.** **Budget:** BARI – $ 2,200; Ohio State – $1,890

## II.1d. Screening of pumpkin germplasm against Watermelon Mosaic 2 Poty Virus (WM2V)

**a. Scientists:** M.A. Rashid, M.A.T. Masud, M.H. Rashid – BARI; M.A. Mannan Akand – BSMRAU; Nazneen A. Sultana, Baha Uddin Ahmed– IPM CRSP; G. Luther – Virginia Tech; L. Black, J.F. Wang – AVRDC

**b. Status:** Ongoing

**c. Objectives:** To (1) locate sources of WM2V resistance in pumpkin germplasm; (2) identify agronomically acceptable resistant line(s) for varietal release; and (3) use resistant sources in variety improvement program. **Objectives in 2002-2003:** To confirm the resistance of the varieties selected in 2001-2002 and identify new sources of WM2V resistance, and make crosses with resistant sources.

**d. Hypotheses:** WM2V of pumpkin is a serious disease in Bangladesh and pesticide use for its control is neither effective nor safe for consumers. Use of resistant cultivars is the most effective tool for its control. A few moderately resistant pumpkin lines have been identified at HRC, BARI. Further screening of the existing pumpkin germplasm will lead to identification of resistant sources. There is a high chance of obtaining agronomically acceptable resistant line(s) for on-farm use and also using the resistant sources for developing pumpkin varieties having high yield and better quality (rich in β-carotene).

**e. Description of research activity:**

Plant materials: The varieties selected as resistant from 2001-2002 experiments and additional germplasm lines collected from local and exotic sources will be artificially inoculated to study their reactions against WM2V under epiphytotic conditions at BARI farm. At the same time, other virus diseases also will be detected using Elisa technique.

Inoculation: The young virus infected leaves of the host plant will be ground with inoculation buffer [Na – phosphate buffer (0.03 M, $P^h$ 7.0 with Na – DIECA, $Na_2So_3$ and activated charcoal)] at the ratio of 1:4 (wt./wt) and filtered through 4 layers of cheese cloth. The test germplasm lines will be inoculated with the buffer solution containing the virus particles (WM2V). A pinch of carborundum powder will be sprinkled on apical leaves before inoculation to abrade the leaves and thus promote virus entry. Inoculation will be done on young apical leaves at two-leaf stage of the plant followed by washing with distilled water.

Data recording: Mosaic symptoms appear between 1 – 4 weeks after inoculation. Five leaves collected from the apical, middle and basal portions of the plant will be tested and graded in a 0 – 5 scale:

a) Highly resistant (HR): No infection - 0
b) Resistant (R): Up to 1 % leaf area infection - 1
c) Moderately resistant (MR): > 1 to 5 % leaf area infection - 2
d) Moderately susceptible (MS): > 5 to 25 % leaf area infection - 3
e) Susceptible (S): > 25 to 50 % leaf area infection - 4
f) Highly susceptible (HS): >50 % leaf area infection – 5.

Records will also be taken on disease incidence, characterization of the germplasm, fruits per plant, average fruit weight (Kg), fruit length and diameter (cm), cavity length and diameter (cm), flesh thickness (cm), flesh color, TSS (%), and days taken for 1st male and female flower to open and their position.

f. **Justification:** In Bangladesh, more than 1 million children have vitamin A deficiency and half of them suffer from night blindness (xeropthalmia). In addition, about 20 to 30 thousand children become blind every year due to chronic vitamin A deficiency. Pumpkin is a good cheap source of vitamins, especially carotenoid pigments. Thus, pumpkin can contribute to improve nutritional status, particularly for vulnerable groups. It has the highest storability as mature pumpkins can be stored for 2-4 months under normal conditions and therefore can meet the demand for vegetables during off season.

g. **Relationship to other research activities at the site:** Mosaic resistant pumpkin varieties can be grown by the farmers in combination with other IPM practices.

h. **Progress to date:** Preliminary results of the ongoing experiments show two varieties having high resistance (no virus infection) and 10 varieties with 0 to 4% infection only.

i. **Projected outputs: (**1) Identification of WM2V resistant sources and utilize agronomically acceptable resistant lines for cultivation by the farmers, (2) Use of resistance sources in variety improvement program.

j. **Projected impacts:** (1) Use of WM2V-resistsant pumpkin varieties will minimize environmental pollution and promote sustainable production; (2) higher yield and improved fruit quality; (3) Enhanced income of the farmers; and (4) Improved nutritional status of the people.

i. **Projected start:** November 2001

l. **Projected completion:** September 2004

m. **Projected person-months of scientist per year:** 6 person-months

n. **Budget:** BARI – $ 2,200

### II.1e. Screening of Okra Germplasm against Yellow Vein Mosaic Virus (YVMV)

a. **Scientists:** M. A. Rashid, M. A. T. Masud, Shahabuddin Ahmed, H. Rashid – HRC (BARI), Md. Hossain-TCRC (BARI), Salim Uddin- Plant Breeding, BARI; Baha Uuddin Ahmed, Nazneen A. Sulatana - IPM CRSP; Sally Miller – Ohio State

b. **Status:** New

c. **Objectives:** (1) To locate sources of resistance to YVMV in Okra germplasm; (2) To utilize the resistant line(s) for developing pest-resistant okra varieties. **Objectives in 2002-2003**: To screen the available okra germplasm for identifying YVMV-resistance.

d. **Hypothesis:** Okra (lady's finger) is a major summer vegetable in Bangladesh. But the varieties currently grown in farmer fields are highly susceptible to YVMV. Farmers use variety of insecticides to control the disease without any success. Many land races are available in the country. It is assumed that extensive collection and screening of okra varieties will lead to identification of YVMV-resistant sources having satisfactory agronomic qualities. Development of pest-resistant okra varieties will be made through identification and utilization of the resistant sources.

e. **Description of research activities:**
Plant materials: A sizeable number of okra germplasm will be collected locally and from exotic sources. These will be inoculated by viruliferous whitefly adults to study their reactions against YVMV under epiphytotic condition.
Culture of whitefly: A pure stock of whitefly species, *Bemisia tabaci,* will be reared and maintained in insect-proof net house on jute or eggplant seedlings for transmission studies.
Vector transmission: The insects will be fed on YVMV infected leaves for 12 to 24 hours. Seedlings of the germplasm under study will be inoculated by viruliferous whitefly adults (10 whitefly/seedling).
Symptoms: The YVMV symptoms will appear in 2 to 4 weeks after inoculation.
Data recording: a) Disease scoring will be noted as per established scale. b) Different horticultural traits of the germplasm along with yield will be recorded.

f. **Justification:** Vegetable production during summer in Bangladesh is constrained due to high temperature, humidity and rainfall. But, okra is one of the few important vegetables available during summer and rainy season. Okra is an excellent source of iodine, which acts against goiter. It is also useful against chronic dysentery. It is a good source of vitamins A and B, and contains vitamin C also. It is also rich in protein and mineral elements. Cultivation of YVMV-resistant okra will greatly help the farmers to obtain higher yield and economic returns and also alleviate malnutrition in children.

g. **Relationship to other research activities at the site:** YVMV resistant okra varieties can be grown by the farmers in combination with other integrated pest management practices.

h. **Progress to date:** New

i. **Projected outputs:** (1) Identification of YVMV resistant sources in okra germplasm; (2) Release of YVMV-resistant okra with better yield and quality; (3) Resistance sources will greatly facilitate okra variety improvement program.

j. **Projected impacts:** Use of okra varieties resistant to YVMV will: (1) minimize environmental pollution and promote sustainable production, (2) raise yield and improve fruit quality, (3) enhance income of the farmers, (4) improve nutritional status of the people, (5) generate employment, and (6) help diversify the export of agricultural produces

**k.** **Projected start:** February 2003

**l.** **Projected completion:** August 2005

**m.** **Projected person-months of scientist's time per year:** 6 person-months

**n.** **Budget:** $ 2200

## II.2a. Management of Lepidopteran Pests in Cabbage Using an Integrated Approach

**a.** **Scientists:** S.M. Monowar Hossain, Salim Reza Mollik, M. Nazimuddin, S.N. Alam, M. Khorsheduzzaman – BARI; Mahbubur Rahman – IPM CRSP; Z. Alam – BSMRAU; N.S. Talekar – AVRDC; E. Rajotte – Penn State; G. Luther – Virginia Tech

**b.** **Status:** Ongoing with expanded activities

**c.** **Objectives:** To minimize the infestation of lepidopteran pests on cabbage using an integrated control approach and produce healthy cabbage crops. **Objectives in 2002-2003**: To test and demonstrate the IPM practice in outreach area of Jessore and Comilla.

**d.** **Hypotheses:** Using an integrated approach of control measures will reduce the populations of *Spodoptera litura,* diamondback moth *(Plutella xylostella), Crocidolomia binotalis* and other lepidopteran pests and will help produce relatively pesticide free cabbage crops.

**e.** **Description of research activity:** There will be three treatments with four replications in RCBD in farmer fields. If possible, one farmer plot will be taken as one block. The treatments are: (1) Farmer practice; (2) Integrated approach: (a) Lepidopteran pests will be hand-picked from the cabbage plants twice per week; (b) If more than 5% of the cabbage heads are infested a blanket Bt spray will be made; (c) On the subsequent sampling dates after Bt spraying, if the heads are still infested with lepidopteran pests, spot treatment will be done with malathion, and (3) Control (no pesticide or hand-picking or other type of treatment).

Plot size will be 7x 6m. The cabbage seedlings will be transplanted in peat in October-November. The experiment will be carried out in Jessore and Comilla districts. Numbers of lepidopteran larvae and pupae will be monitored and recorded twice per week in cabbage. Data will be recorded on predators and parasitoids. Cabbage head weight, size, and compactness will be recorded for all plots.

**f.** **Justification:** Lepidopteran leaf feeders are serious pests of cabbage in Bangladesh. Farmers make frequent applications of insecticides to control these pests with little success. Since cabbage is a quick-growing vegetable, it is very likely that insecticides sprayed on cabbage will have residues that will eventually appear in the food chain. This experiment will assist the farmer in producing cabbage with minimal insecticide applications, thereby reducing production costs and ensuring less toxic produce.

g. **Relationship to other research activities at the site:** This will be a part of the IPM program. Information on pest control and natural enemies of these insects may be shared with other projects.

h. **Progress to date:** Two trials were conducted in 1999–2000 and 2000-2001. Pest infestations were very low in the first year and moderate in the second year. Bt appeared to be effective against the lepidopteran pests during the first year. In the second year, however, two hand-pickings of lepidopteran pests gave effective control of the pests compared with five insecticidal applications made by the farmers.

i. **Projected outputs:** Improved knowledge of integrated pest management in cabbage to control lepidopteran pests.

j. **Projected impacts:** Improved farmer knowledge in insect pest management on cabbage will be the driving force to obtain higher yields, better quality produce and thereby higher income. Pesticide applications will be reduced and this will have a positive impact on the environment and human health.

k. **Project start:** October 1998

l. **Projected completion:** April 2003

m. **Projected person-months of scientists time per year:** 12 person-months

n. **Budget:** BARI – $ 3,630; Virginia Tech – $1,270

### II.2b. Assessment of Virus Infestation at Different Stages of Okra Plants

a. **Scientists:** S.M. Monowar Hossain, Salim Reza Mollik, M. Nazimuddin, S. N. Alam, M. Khorsheduzzaman – BARI; Mahbubur Rahman – IPM CRSP; Z. Alam – BSMRAU; E. Rajotte – Penn State; G. Luther – Virginia Tech; S. Miller – Ohio State

b. **Status:** Continuing

c. **Objectives:** To measure the degree of virus infestation (YMV) at different stages of okra plant growth by the vectors (white fly) so that appropriate control measures can be undertaken at the critical stage of vector infestation and virus transmission. **Objectives in 2002-2003:** To identify the growth stage(s) of okra plants which is critical for vector (white fly) infestation and YMV transmission and incorporate control measures with insecticides.

**d.** **Hypothesis:** Vectors usually attack young okra plants at the vegetative stage for virus transmission. Appropriate control measures for vector or virus transmission can be undertaken based on the growth stage of okra.

**e.** **Description of research activity:** The experiment will be conducted at BARI Farm with the following treatments having three replications in split plot design maintaining plant spacing of 50cm x 40cm; unit plot size will be 2m x 2m.

Main plot treatment: Variety – (a*)* Pusa Sawni (susceptible) and (b) BARI Dherosh-1 (resistant)

Sub-plot treatment: 2m high nylon net barrier around the plots

| | |
|---|---|
| $C_0$ | No net barrier (control) |
| $C_1$ | Net barrier 7 days after emergence of plants |
| $C_2$ | Net barrier 14 days after emergence of plants |
| $C_3$ | Net barrier 21 days emergence of plants |
| $C_4$ | Net barrier 28 days after emergence of plants |
| $C_5$ | Net barrier 35 days after emergence of plants |
| $C_6$ | Net barrier 42 days after emergence of plants |
| C7 | Net barrier from planting to harvest |
| C8 | Weekly insecticide applications up to 5 weeks |
| C9 | Biweekly insecticide applications up to 5 weeks |
| C10 | Weekly insecticide applications from planting to fruiting |

Okra will be grown following standard practices and by applying cow dung at 5 t/ha, and NPK at the rate of 40-50-90 kg/ha in the main field. Twenty five percent of the plants in each treatment will be sampled for recording all the parameters. Infestation of okra plants by yellow vein mosaic virus will be observed under field condition and confirmed by ELISA test. The number of white flies per leaf of okra plants will be recorded every 7 days starting from one week after emergence. Data will be recorded on the following: (1) No. of white flies per leaf before and after placing net barrier; (2) Percent plants infected by YMV; (3) Days to $1^{st}$ flowering, (4) No. of primary and subsequent branches; (5) Days to first and last harvest; (6) Plant height (cm) at maturity; (7) Fruit length and diameter (cm); (8) No. of fruits/plant; (9) Yield/plot (kg).

**f.** **Justification:** Yellow vein mosaic virus, commonly known as YMV (yellow mosaic virus) is a serious problem in okra transmitted by white fly. As a consequence YMV infestation becomes severe particularly in plants susceptible to the vectors. Moreover, plants become weak due to attack of the vectors. YMV symptoms are normally noticeable in severe form at the fruiting stage when farmers apply insecticides randomly to control the vectors. It is necessary to ascertain the proper stage of plant growth when the virus transmission by vectors is critical. This information will help to develop appropriate control measures of vectors, which will eventually minimize pesticide application.

**g.** **Relationship to other research activities at the site:** If this component technology is found effective, it can be incorporated into an IPM package for the control of virus vectors in other vegetable crops.

**h.** **Progress to date:** The results of 2001 summer season trial showed that exclusion of YMV vectors for 4 weeks or more by the use of 2m high net barrier around the okra plants decreased the populations of vectors and YMV infected plants of resistant or susceptible okra varieties. Low virus infection in the netted plots increased the yields by 3-3.5 times in resistant variety and 2-2.5 times in susceptible variety.

**i.** **Projected outputs:** Effective and improved control measures of vectors transmitting YMV in okra plants and increased yield.

**j.** **Projected impacts:** This finding would eventually minimize the pesticide application in okra plants for controlling vectors of yellow mosaic virus.

**k.** **Projected start:** March 2001

**l.** **Projected completion:** June 2004

**m.** **Projected person-months of scientists' time per year:** 6 person-months

**n.** **Budget:** BARI – $ 2,200; Ohio State – $1,890; Virginia Tech – $1,270

**ll.2c. Off-season vegetable production under integrated pest management**

**a.** **Scientists:** S.M. Monowar Hossain, Mozammel Hoque, Salim Reza Mollik, M. Nazimuddin, S. N. Alam, M. Khorsheduzzaman – BARI; Baha Uddin Ahmed – IPM CRSP; Z. Alam – BSMRAU; S. Islam – DAE (PPW); E. Rajotte – Penn State; G. Luther – Virginia Tech.; L. Black – AVRDC.

**b.** **Status:** Continuing

**c.** **Objectives:** (1) produce vegetables and increase their availability during the off-season and (2) produce pesticide-free vegetables. **Objectives in 2002-2003:** To determine the potential of growing cabbage and tomato crops during the off-season (summer) using heat-tolerant varieties and to produce okra crop during off-season (winter) by using nylon net and polythene barriers.

**d.** **Hypothesis:** Production of off-season vegetables using tolerant off-season varieties will increase availability of the vegetables in the market and bring higher economic returns to farmers. Protective structures for such vegetables will reduce the pest infestation, and therefore pesticide usage will be minimized to produce vegetables safe for consumption.

e. **Description of research activity:** The experiment will be set up at BARI farm with the following three treatments having four replications in RCB design under sequential cropping system in unit plots of 2.5m x 20m (50 $m^2$).
Crops under sequential cropping system: Summer Cabbage (March-May); Summer tomato (June-Sept) – Okra (Oct-Feb)
Varieties: Tomato- BARI tomato- 5/ Anupuma; Okra-BARI Dherosh-1; Cabbage- KK cross.
Treatments: T1- Net on all sides + polythene top; T2- Polythene top only; and T3- Control (without net or polythene barrier).
Data to be recorded: Percentage of pest infested plants by fruit worm, aphids and white flies (TYLCV) on tomato; jassids, leaf hopper and white fly (YMV) on okra; diamondback moth, cabbage web worm, *Spodoptera* and bacterial soft rot on cabbage; crop growth and yield parameters; temperature and humidity for different treatments; cost benefit analysis.

f. **Justification:** Summer is the off-season for tomatoes and cabbage, while winter is for okra. These vegetables have high value during the off-season, but their production is constrained by biotic and abiotic stresses. Cultivation of these three vegetables with stress tolerant varieties under protective structures is likely to increase the supply during the slack periods. At the same time, protective measures for growing the vegetables will reduce pest infestation and pesticide use and will help produce safe vegetables.

g. **Relationship to other research activities at the site:** Production of off-season vegetables can be utilized in farmer fields in combination with other IPM strategies.

h. **Progress to date:** Okra (variety BARI Dherosh-1) was grown from December 2001 to April 2002. Preliminary results show that okra grown during the winter months (off-season) under poly-tunnels has better growth and yields than when grown normally without poly-tunnels.

i. **Projected outputs:** Growing vegetables during the off-season without pesticide use or minimal pesticide use will increase market availability of healthy vegetables during the off-season and will increase the economic benefit to farmers.

j. **Projected impacts:** (1) Supply of these vegetables in the market throughout the year would be made possible and (2) Commercial vegetable growers in the peri-urban areas would benefit.

k. **Projected start:** October 2001

l. **Projected completion:** September 2004

m. **Projected person-months of scientists' time per year:** 6 person-months

n. **Budget:** BARI – $ 2,420; Virginia Tech – $1,270

## II. 3. Patterns and Rates of Fruit Fly (*Bactrocera cucurbitae*) Infestation on Different Cucurbit Vegetables and its Management

a. **Scientists:** M. Nasiruddin, S.N Alam, M. Khorsheduzzaman – BARI; A.N.M.R. Karim, H. S. Jasmine- IPM-CRSP; E.G. Rajotte - Penn State; G. Luther- Verginia Tech

b. **Status:** Continuing with new activities

c. **Objectives (Current and overall):** (1) To identify the cucurbit crops most preferred by fruit flies and their infestation/damage rates; (2) To test and demonstrate the efficacy of mass-trapping by pheromone and indigenous bait traps for fruit fly control in cucurbits without pesticide use; and (3) to demonstrate the usefulness of IPM package for fruit fly control in highly fruit fly endemic area.

d. **Hypotheses:** (1) Fruit fly infestation rates vary in different cucurbits. Identification of more susceptible cucurbits will help in designing and deploying the appropriate management measures; most susceptible crops can be used as trap crops; (2) The pheromone and indigenous bait traps, found to be highly effective at Kashimpur area, should also perform equally effective in a new area and the results will greatly help in developing an IPM package for fruit fly control; and (3) A preliminary IPM package developed from earlier results will provide feedback information from the farmers regarding fruit fly control in highly endemic areas.

e. **Description of research activity:** Three types of experiments will be carried out to understand fruit fly infestation dynamics on different cucurbits and to evaluate and demonstrate IPM-based fruit fly control tactics in farmer fields.

Patterns and rates of fruit fly infestation on different cucurbit crops: Crops of ten kinds of cucurbits will be raised at BARI farm, Gazipur: Bottle gourd (in winter), cucumber, bitter gourd (in early summer), ash gourd, sweet gourd, ribbed gourd, snake gourd, sponge gourd, teasel gourd, and pointed gourd (in late summer). Data will be collected on fruit infestation and its severity, number of healthy and damaged fruits, and weather components (temperature and rainfall).
Evaluation of mass-trapping with pheromone and indigenous bait traps for fruit fly control: The test will be conducted at Sripur (a new area) of Gazipur evaluate the efficacy of the bait traps earlier found to be highly effective for fruit fly at Kashimpur area. Four treatments will be established in three replications in different farmer fields: $T_1$- Cuelure trap (male sex pheromone); $T_2$ - Cuelure + mashed sweet gourd trap; $T_3$ - Mashed sweet gourd trap; and $T_4$ - Untreated control. Data will be collected weekly on the number male and female flies caught, healthy (uninfested) fruits, partially infested but marketable fruits, and fully infested, non-marketable fruits, and weather components (temperature and rainfall). Economic analysis will also be done.
Evaluation of IPM package for fruit fly control: The trial-cum-demonstration will be conducted in farmer fields at Sitakund area of Chitagong district, a highly cucurbit fruit fly endemic area. Three treatments will be laid out in three replications in different farmer fields: $T_1$- IPM approach (Cuelure + mashed sweet gourd traps + sanitation); $T_2$-

Farmer practice; and $T_3$- Untreated control. Data will be collected weekly on the number male and female flies caught, healthy (uninfested) fruits, partially infested but marketable fruits, and fully infested, non-marketable fruits, and weather components (temperature and rainfall). Economic analysis will also be done.

**f.** **Justification:** Cucurbit fruit fly has a wide range of cucurbit hosts, therefore its infestation patterns and rates are not similar on different host. The levels of management measures can be adopted according to the susceptibility of the crops. Moreover, the most susceptible crops can be used as trap crops. Efficacy of the bait traps already found effective at Kashimpur area may vary due to weather conditions or differences in fruit fly species. Evaluation of the bait traps in new areas will provide feedback on its suitability across geographical locations. Similarly, test of a preliminary IPM package developed from earlier findings will provide information on its efficacy and farmer acceptance for the control of fruit fly.

**g.** **Relationship to other CRSP activities at the site:** This activity will produce important information on fruit fly infestation patterns and greatly help to develop practical fruit fly management tactics without or least use of pesticides.

**h.** **Progress to date:** Bait traps of cuelure pheromone and mashed sweet gourd (MSG) in cucumber and sweet gourd have been highly effective to attract large number of fruit flies resulting in more than 50% reduction of fruit damage and producing more than two-fold crop yields.

**i.** **Project output(s):** Improved knowledge of (1) fruit fly infestation patterns and rates on different cucurbit crops; and (2) development of IPM-based fruit fly management in different cucurbits across locations.

**j.** **Project Impacts:** Integrated management of fruit fly will greatly help to establish a cost-effective, environmentally safer pest protection strategy for cucurbit crops and also create opportunities for export.

**k.** **Project Start:** October 2002

**l.** **Project completion:** September 2004

**m.** **Project person-months of Scientists time:** 8-man month

**n.** **Budget:** BARI – $ 5,060

## II.4. Development of an Integrated Management Package for the Control of Eggplant Shoot and Fruit Borer (ESFB)

a. **Scientists name:** S.N Alam, M. Khorsheduzzaman, Sahadat Hossain – BARI; A.N.M.R. Karim, Nazneen A. Sultana - IPM-CRSP; E.G. Rajotte - Penn State; G..Luther- Verginia Tech

b. **Status:** New

c. **Objective (current and overall):** To establish an IPM-based, environment-friendly, and cost-effective package for the control of fruit and shoot borer of eggplant.

d. **Hypothesis:** FSB of eggplant is a difficult pest to control with the use of unilateral measures. Presently, farmers' indiscriminate use of pesticides has not only complicated its management, but has also created a hazardous situation for the growers and the consumers. Integration of different tactics, such as sanitation, host plant resistance, and grafting will produce cumulative adverse effects on FSB population and help greatly to reduce FSB infestation on eggplant in farmers' field.

e. **Description of research activity:** The trials will be conducted in farmer fields at Sripur (Gazipur) and Jessore in three replications with the following treatments: $T_1$=Sanitation (removal and destruction of infested shoot and fruit); $T_2$ = Sanitation + use of FSB-resistant eggplant variety; $T_3$ = Sanitation + use of resistant-grafted eggplant; $T_4$ = Sanitation + use of non-resistant grafted eggplant variety; $T_5$ = Farmer practice; and $T_6$ = Untreated control. The unit plot size will be 5m x 5m. Data will be recorded weekly on infested and non-infested shoots and fruits from 10 $m^2$ area of each replication. Weight of infested and healthy fruits from 10 $m^2$ area will be recorded during each harvest and analysis of inputs and outputs will be done.

f. **Justification:** Eggplant fruit and shoot borer is a serious pest of eggplant. Presently, only toxic insecticides are used to control the pest with least or no effect as the pest has developed resistance to most of the common pesticides. On the other hand, indiscriminate insecticide use has complicated FSB management and has also created environmental pollution and health hazards. Studies have shown that sanitation in eggplant fields can reduce the initial population of FSB and the use of resistant eggplant varieties and grafted eggplants can cumulatively suppress population build up of FSB. So, the combination of these tactics can reduce the pest population and keep it below economic threshold level.

g. **Relationship to other CRSP activities at the site:** This package of tactics, if found effective, can be combined with other effective practices to develop a more flexible IPM package for the control of FSB.

h. **Project output(s):** Development of an integrated management practice with least or no environmental pollution, low cultivation cost and high returns.

i. **Project Impacts:** Low FSB population with low damage to eggplants will ultimately increase yields and production of eggplants free of toxic insecticide.

j. **Progress to date:** New activity

k. **Project Start:** October 2002

l. **Project completion:** September 2004

m. **Project person-months of Scientists time:** 8-man month

n. **Budget:** BARI – $ 3,850; Virginia Tech – $2,540

## II.5. Integrated Management of Weeds and soil-borne Diseases in Eggplant and Tomato

a. **Scientists:** Anwar Karim, S.A. Khan – BARI; A.N.M.R. Karim, Mahbubur Rahman– IPM CRSP; A. Baltazar – NCPC/UPLB; Sally Miller – Ohio State; S.K. De Datta – Virginia Tech

b. **Status:** New

c. **Objectives (current and overall):** To evaluate the effects of soil amendment practices (1) on weed proliferation and their role to act as latent host of soil-borne diseases; and (2) overall suppression of soil-borne diseases of vegetable crops through soil amendments.

d. **Hypotheses:** Organic soil amendments with poultry refuse and mustard oil-cake have been found to effectively control various soil-borne diseases in vegetable crops. But, this practice has the potential to induce weed proliferation and also to act as latent host of some soil-borne pathogens. In order to use a package for the management of weeds and soil-borne diseases, it is necessary to evaluate the effects of soil amendments to achieve the objectives.

e. **Description of research activity:** The trials will be conducted in farmer fields at Sripur and Kashimpur on eggplant and tomato. The following treatments in unit plots of 5m x 5m will be laid out in RCB design in four replications: $T_1$ – Poultry refuse + one hand weeding (HW) at 20 DAT (days after transplanting); $T_2$ – Poultry refuse + two HW at 20 and 40 DAT; $T_3$ – Mustard oil-cake + one HW at 20 DAT; $T_4$ – Mustard oil-cake + two HW at 20 and 40 DAT; $T_5$ = One HW at 20 DAT (no poultry refuse or mustard oil-cake); $T_6$ = Two HW at 20 and 40 DAT (no poultry refuse or mustard oil-cake); $T_7$ - Farmer practice; $T_8$ - No weeding (no poultry refuse or mustard oil-cake). Poultry refuse and mustard oil-cake will be mixed with the soil about 15 days before the final preparation of the crop field. Data will be recorded on (1) fresh and dry weight of weeds by species at 20, 40 DAT and 2 weeks before harvest, (2) crop yield and other yield components, (3) number of days to crop maturity, and (4) time spent for hand weeding (min/plot or hour/crop). Economic analyses for inputs and outputs will be done.

f. **Justification:** Crop production involves a number of management practices in order to achieve the desired yield. For management of weeds, diseases and other pests, farmers will usually look for a package of practices that may solve their problems. Organic soil amendments with poultry refuse and mustard oil-cake can effectively control soil-borne diseases, but their effects on weed management is little known. There is need therefore to evaluate the effects of soil amendments for the management of weeds and diseases at the same time.

**g.** **Relationship to other research activities at the site:** This activity, if found effective, can be incorporated with other IPM practices to develop a suitable package for the management of weeds and other pests.

**h.** **Progress to date:** Results of the weed control experiments so far carried out from 1999 to 2001 winter season on cabbage, eggplant and okra have shown that weed control operations at the critical crop growth stages (15-20 DAT and 35-40 DAT) can effectively control the predominant weeds without reducing the yields and thus can cut down the weeding costs by about 50% and bring about better economic returns to the farmers. Similarly, organic soil amendment treatments were highly effective for the control of soil-borne diseases in different vegetable crops and produced high yields giving excellent crop stand and economic returns.

**i.** **Projected outputs:** Cost effective weed and disease management scheme will be available to vegetable growing farmers.

**j.** **Projected impacts:** Development of a sustainable weed and disease management package, reduced production cost and increased profit.

**k.** **Projected start:** October 2002

**l.** **Projected completion :** September 2004

**m.** **Projected person-months of scientists time per year:** 6 person-months

**n.** Budget: BARI – $ 2,970; Ohio State – $1,260

## II.6. Integrated Management of Soil-Borne Pathogens of Eggplant, Cabbage, Tomato, Pointed gourd and Cucumber in Farmer Fields in Jessore and Gazipur (Sripur)

**a.** **Scientists**: M.A. Rahman, Khorshed Alam, K.A. Kader, M.I. Faruk – BARI; Haider Hossain – RARS, BARI (Jessore); H.S. Jasmine, Mahbubur Rahman – IPM CRSP; S. Miller – Ohio State; L. Black – AVRDC

**b.** **Status:** Continuing with expanded activities

**c.** **Objectives (current and overall):** To confirm the previous results of the use of sawdust burning, poultry refuse and mustad oil-cake obtained at Kashimpur, and to demonstrate the usefulness of soil amendment practices with sawdust, poultry refuse and mustard oil-cake in eggplant, cabbage, pointed gourd, tomato and cucumber crops in farmer fields of new areas of Gazipur and Jessore districts.

**d.** **Hypothesis**: Soil amendments reduce the populations of soil-borne pathogens in a number of vegetable crops and help establish satisfactory crop stand to produce higher yields and bring about higher economic returns.

**e.** **Description of research activity**: Soil amendment demonstration trials in seedbed nurseries with sawdust burning and that with the use of poultry refuse and mustard oil-cake in the main fields of eggplant, cabbage, tomato and pointed gourd will be conducted at Jessore and Sripur areas. In each of the areas, 1-2 farmer fields will be selected for each crop. The trials will be laid out in RCB design with 4 replications. There will be four treatments in the seedbed nurseries: $T_1$ = Saw dust burning; $T_2$ = Incorporation of poultry refuse; $T_3$ = Incorporation of mustard oil-cake; $T_4$ = Farmer practice; and $T_5$ = Untreated control. The seedbed nurseries (unit plot of 2.5m x 1m) will be covered by a 6cm thick layer of sawdust and then burned thoroughly. Poultry refuse (3t/ha) and mustard oil-cake (300Kg/ha) will be applied about 15 days before the final preparation of the seedbeds. In the main crop fields, four treatments will be established: $T_1$= Incorporation of poultry refuse; $T_2$ = Incorporation of mustard oil-cake; $T_3$ = Farmer practice; and $T_4$ = untreated control. Poultry refuse (3t/ha) and mustard oil-cake (300kg/ha) will be incorporated with the soil about 15 days before the final preparation of the main field. The nursery beds and the crop fields will be observed weekly and data will be collected on crop growth, disease incidence and plant mortalities, and yields. Economic analyses for inputs and outputs will be made.

**f.** **Justification:** Seed and soil-borne pathogens viz., *Rhizoctonia* spp., *Fusarium* spp., *Pythium* sp., *Ralstonia solanacearum* and *Meloidogyne* spp. cause seed and seedling diseases in almost all the vegetable crops in the seedbed nurseries as well as in the main fields. A single approach is not helpful to minimize disease complex of the crops. Application of organic amendments would help to minimize the incidence of soil –borne diseases and increase their yields.

**g.** **Relationship to other CRSP activities at the site:** Integrated disease management research will complement the weed and insect management research on these crops in other places.

**h.** **Progress to date:** Previous experiments have shown that soil amendments with the use of sawdust, poultry refuse and mustard oil-cake can effectively control various soil-borne disease pathogens in various vegetable crops and can enhance the yields, thereby increasing economic returns of the farmer.

**i.** **Projected outputs:** Improved knowledge about disease problems and environmentally safe, effective disease management practices with higher returns.

j. **Projected impacts:** (1) Improved understanding of integrated disease management of vegetable crops among the growers; (2) Reduced incidence of various disease pathogens; (3) Reduced dependence on chemical control; and (4) Higher yields of vegetables.

k. **Projected start:** September 2001

l. **Projected completion:** September 2003

m. **Projected person-months of scientist time**: 7 persons-month

n. **Budget:** BARI – $ 4,070

## III. Multidisciplinary Laboratory, Greenhouse, and Microplot Experiments

### III.1 Study of Biology of *Trichogramma* on *Leucinodes* Eggs and *Trathala flavo-orbitalis* on *Leucinodes* Larvae and their Parasitism Efficiency on FSB under Laboratory and Field Conditions

a. **Scientists:** S.N. Alam, M. Khorsheduzzaman, Shahadat Hossain – BARI; A.N.M.R. Karim, Nazneen A. Sultana – IPM CRSP; N.S. Talekar –AVRDC; E. Rajotte – Penn State; G. Luther – Virginia Tech

b. **Status:** Continuing

c. **Objective(s):** To (1) rear the egg parasitoid *Trichogramma sp.* on *Corcyra cephalonica* and *Trathala flavo-orbitalis* on *Leucinodes* larvae; (2) standardize *Corcyra* egg density and *Trichogramma* parasitoid density on cards; (3) determine the parasitism efficiency of *Trichogramma* and *Trathala flavo-orbitalis* for the control of *Leucinodes* in the laboratory, greenhouse and field; and (4) determine the existing egg parasitoid species in the field. **Objectives in 2002-2003:** (1) To rear the egg parasitoids in the laboratory and test their parasitism efficiency on eggplant fruit and shoot borer in the green house and partly in the field; and (2) To record the incidence of egg parasitoids in intensive eggplant growing areas.

d. **Hypothesis:** Biological control will suppress the population of eggplant fruit and shoot borer and help grow eggplants with minimal or no insecticide applications.

e. **Description of research activity:**

Activity with Trichogramma- The egg parasitoid *Trichogramma sp.* will be reared on the eggs of *Corcyra cephalonica* by standardizing *Corcyra* egg density and *Trichogramma* parasitoid density on cards. The density of *Corcyra* eggs will be calculated by counting the eggs on 20 cards according to portion of the card covered by eggs. The number of *Trichogramma* that will emerge from 'x' number of eggs will be counted. To determine the functional response of *Trichogramma* parasitization of *Leucinodes* eggs, varying numbers of *Trichogramma* will be released on various numbers of *Leucinodes* eggs, and the number of *Trichogramma* emerging will be counted. Parasitism rates will be assessed.

FSB eggs parasitized by *Trichogramma* will be placed at 6-10° C to determine how long *Trichogramma* can be stored and at what temperatures. *Trichogramma* sp.will be tested on *Leucinodes* eggs to determine the parasitism efficiency for the control of *Leucinodes orbonalis* in the laboratory and in the field (under controlled conditions); comparisons will be made between plots with *Trichogramma* releases and plots with no releases. Collection and rearing of *Leucinodes* eggs will be continued to determine the existing egg parasitoid species in the field.

Activity with *Trathala flavo-orbitalis*- This larval parasite will be reared on the larvae of *Leucinodes*. Several third-instar larvae of *Leucinodes* will be released in a petri dish having artificial diet and will be placed in a rearing cage. One male and female *Trathala* will then be placed inside the rearing cage with *Leucinodes* larvae. The parasitized *Leucinodes* larvae will be replaced with fresh ones at 24 hour intervals. The parasitized larvae will be put in another rearing cage for the release of *Trathala*. *Trathala flavo-orbitalis* will be tasted on Leucinodes larvae to determine the parasitism efficiency for the control of *Leucinodes orbonalis* in the laboratory, greenhouse and in the field(under controlled conditions); comparisons will be made between plots with *Trathala flavo-orbitalis* releases and plots with no releases. Collection and rearing of *Leucinodes* infested shoots and fruits will be continued to determine the existing parasitoid species in the field.

**f.** **Justification: (**1) Bio-control methods can reduce the population of *Leucinodes orbonalis* in eggplant, thereby reducing environmental pollution from chemical control; (2) Chemical control causes health hazards and secondary mite infestation; and (3) Farmers currently spray each crop about 40-180 times per season; IPM will help to produce insecticide-free vegetables and open up avenues for exporting to different countries.

**g.** **Relationship to other research activities at the site:** The proposed work on biological control will provide IPM tactics to complement other IPM methods in eggplant, such as use of resistant/tolerant eggplant varieties.

**h.** **Progress to date:** Identified *Trichogramma chilonis* (Ishii) as one of the major parasitoids that parasitizes *Leucinodes* eggs. It has been successfully reared on *Corcya cephalonica* eggs*. Trathala flavo-orbitalis*, on the other hand, has been reared in the laboratory and it has proved to be an efficient larval and pupal parasite of eggplant FSB in the greenhouse. Facilities for bio-control laboratory and techniques have been developed to a satisfactory level.

**i.** **Projected outputs:** Enhanced Bio-control laboratory. A biocontrol method developed for managing *Leucinodes*.

**j.** **Projected impacts:** (1) Reduced pesticide use; (2) Increased eggplant yield and farmers income.

**k.** **Projected start:** October 1998

**l.** **Projected completion:** September 2004

m. **Projected person-months of scientists time:** 8 person-months

n. **Budget:** BARI – $2,970; Virginia Tech – $1,270

## IV. Socioeconomic Analyses

### IV.1. Measure Economic Impacts of Bangladesh IPM CRSP Research Activities

a. **Scientists:** M.I. Hossain, M. A. Monayem Miah, Nazrul Islam– BARI; H. S. Jasmine, Nazneen A. Sultana, Mahbubur Rahman, Baha Uddin Ahmed – IPM CRSP; G. Shively – Purdue; G. Norton – Virginia Tech

b. **Status:** Continuing

c. **Objectives:** (1) Evaluate and forecast economic impacts resulting from pest management strategies (PMS) developed by the IPM CRSP Bangladesh; (2) Estimate potential country-wide impacts of PMS developed by the IPM CRSP Bangladesh; and (3) Incorporate experimental and baseline survey data in a farm-level optimization model to analyze the potential farm level impact of IPM practices for representative farms. **Objectives in 2002-2003:** Continue evaluation of the farm level and aggregate impacts of the latest IPM strategies developed on the project, and preparation of a paper out of the Debass thesis and complete the optimization study.

d. **Hypotheses:** (1) Tested IPM practices will result in higher income for farms that adopt IPM; and (2) IPM practices will generate economic benefits to Bangladesh society as a whole.

e. **Description of research activity:** Individual scientists will collect data to be used to develop economic budgets for IPM components and packages. These budgets include production costs and financial returns. IPM packages will be assessed regarding their requirements of farm resources such as land, labor, and cash at specific times in the agricultural calendar. Economic surplus analysis will be used to project national-level impacts of IPM adoption.

f. **Justification:** Knowledge regarding the farm-level profitability of IPM strategies is necessary for promoting IPM and predicting likely patterns of adoption. Knowledge regarding potential aggregate social benefits of IPM adoption is necessary for informing national policy makers and research directors of the overall merits of IPM strategies and their economy-wide impacts. Information can also be used to develop specific policies to encourage IPM adoption. Technology transfer to other settings requires information regarding the likely settings in which adoption is expected to occur.

g. **Relationship to other research activities at the site:** This work is very closely related to research being conducted by other IPM CRSP scientists. This research critically depends on accurate and timely contributions of data from other research scientists. The activity specifically addresses issues related to the private profitability of IPM strategies being developed by other IPM CRSP scientists. It also complements other socioeconomic research that focuses on IPM adoption and the role of prices and marketing in pest management decisions for vegetables.

h. **Progress to date:** Partial work on the above objectives has been done and the impacts of three new technologies developed by IPM CRSP Bangladesh have been evaluated with an MS thesis prepared. In 2001-2002, preliminary evaluation of new data of three more technologies has been prepared.

i. **Projected outputs:** The profitability of IPM components and packages will be estimated and reported in a series of papers and presentations to the research community and policy makers in Bangladesh.

j. **Projected impacts:** Better decision making among researchers and policy makers regarding appropriate IPM technologies and likely on-farm impacts.

k. **Projected start:** September 2000

l. **Projected completion:** September 2004

m. **Projected person-months of scientists time per year:** 6 person-months

n. **Budget:** BARI – $ 1,320; Virginia Tech – $10,573; Purdue – $17,261

### IV.2. Socioeconomic Factors Effecting Pest Management Practices and Adoption of Integrated Pest Management Practices in Different Regions of Bangladesh

a. **Scientists:** M.I. Hossain, M. A. Monayem Miah, Nazrul Islam– BARI; Baha Uddin Ahmed, Nazneen A. Sultana – IPM CRSP; C. Sachs – Penn State; G. Shively – Purdue; G. Norton – Virginia Tech.; Fakhrul Islam -- BSMRAU

b. **Status:** Continuing

c. **Objectives:** (1) assess farmers' knowledge and perceptions of pest management practices in different regions; (2) assess the relative importance of agronomic, economic and social factors explaining observed patterns of crop and pest management practices; (3) determine the effect of IPM practices on labor allocation (especially women's labor allocation) within farm households; (4) determine the extent of adoption of pest management practices of vegetables in different regions; (5) determine differences between men and women's knowledge and use of different pest management practices and (6) examine the effectiveness of IPM programs in facilitating improved pest management practices. **Objectives in 2002-2003:** To analyze the data of the PRA and the adoption practices followed by the farmers in different locations.

**d.** **Hypotheses:** (1) Probability of pesticide use rises as the intensity of vegetable production on a farm increases; (2) Socio-economic and demographic characteristics of households and their members affect adoption of IPM practices; (3) Adoption of IPM practices affect demand for labor use in farm households and may affect women's time allocation and health; (4) Regional differences in on-farm employment and labor availability of both men and women influences adoption of IPM practices.

**e.** **Description of research activity:** Data will be collected on pest management practices in four regions: Comilla, Mymensingh, Jessore and Rangpur. We will study two villages in each district. In each region, data will be collected in two stages. First, Participatory Rural Appraisals (PRA) will be conducted for selected informant groups in each study area. This will assess overall pest management scenarios and perceptions of vegetable farmers in the country. Second, a baseline survey will be conducted in each study area for detail, in-depth information and more representative results on socio-demographic and pest management practices of vegetable cultivation. For the PRA and baseline survey, purposive and random sampling procedures will be followed respectively. Three categories of key informant focus groups will be interviewed for the PRA: i) men, ii) women, and iii) professional groups (e.g., DAE, NGO, bankers, vegetable traders and exporters). These focus groups will be conducted in each village and each group will include 8-10 members. Semi-structured questionnaire and checklists will be used for PRA survey. For the baseline survey, the sample will consist of 480 people. In each village, we will select 30 men and 30 women respondents for a total of 120 respondents from each district to be selected to interview.

The baseline survey will be a structured questionnaire that will be pre-tested. Trained enumerators and researchers will collect the survey data. Qualified university graduates can be hired as enumerators for collecting primary data. The survey will be conducted from March to October 2003. Both qualitative and quantitative data of PRA and baseline survey will be analyzed as per objectives of the study. Data from baseline survey will also be used to classify major pest management practices. Probability and extent of adoption of the practices will be assessed using statistical models (probit/logit, and/or other multiple regression methods). Data from the focus groups will be analyzed to enrich the findings from the baseline survey.

**f.** **Justification:** Understanding of the factors associated with different pest management practices is necessary for formulating policies to promote new pest management practices or discourage undesirable practices.

**g.** **Relationship to other research activities at the site:** This work complements other socioeconomic research on the IPM CRSP in Bangladesh. Other activities related to this include the impact assessment and the price and marketing study. Data from baseline study will be used as input.

**h.** **Progress to date:** PRA in different locations and data on adoption of IPM technologies by the farmers are being collected.

i. **Projected outputs:** Paper and presentations to research community and policy makers in Bangladesh.

j. **Projected impacts:** Better understanding of pest management practices and improved policy making within the Department of Agriculture.

k. **Projected start:** September 2001

l. **Projected completion:** September 2004

m. **Projected person-months of scientists' time per year:** 6 person-months

n. **Budget:** BARI – $ 9,150; Virginia Tech – $3,810; Purdue – $17,261

## IV.3. Integration and Diffusion of IPM Technology

a. **Scientists:** M.I. Hossain, S.N. Alam, M.A. Monayem Miah, M. Nazrul Islam , M. A. Rahman– BARI; M. Ataur Rahman – CARE-Bangladesh; Baha Uddin Ahmed, Nazneen A. Sultana – IPM CRSP; G. Shively – Purdue; G. Norton, G Luther – Virginia Tech; Madonna Casimero – IRRI

b. **Status:** New

c. **Objectives:** (1) test the most promising set of technologies developed by the IPM CRSP with the participation of farmers; (2) obtain farmers' feedback about these technologies including the constraints related to their implementation; (3) find the economic advantages of the technologies; and (4) facilitate diffusion of IPM technologies. **Objectives in 2002-2003:** To test the most promising technologies with farmer participation and obtain farmers' feedback and assess economic advantages of the technologies.

d. **Hypotheses:** (1) IPM technologies will be accepted by the farmers; (2) Farmers' participation will enhance the expansion of IPM technologies; and (3) IPM practices will be economically advantageous to farmers.

e. **Description of research activity:** Three study areas namely Jessore, Comilla and Rangpur will be selected for the study. Two villages will be selected from each study district based on the related technology-based vegetable growing area and five farmers will be selected from each village to participate in testing the IPM CRSP derived technologies. For the selection of the farmers, the help of the NGOs involved in the areas will be considered. The help of one vegetable scientist from RARS, Jessore and two vegetable scientists from the Headquarters will be taken for the study. The farmers will be selected from small, medium and large farm categories. Before the actual start of the work in the farmer fields, the selected farmers will be trained on IPM-derived technologies, which will be used in their fields. The information regarding the technologies, farmers' perceptions, constraints, etc. will be recorded in a regular basis by the enumerators. At the same time, the existing practices of the farmers with the selected vegetables in the areas will be recorded.

**f.** **Justification:** IPM scientists have developed a number of technologies that need to be disseminated to the farmers. In addition, feedback regarding these practices is needed for further improvement and policymaking decisions.

**g.** **Relationship to other CRSP activities at the site:** This has an important relationship to all other activities at the site, because this activity allows impact to occur at the farmers' level through dissemination of technologies.

**h.** **Progress to date:** In 2001-2002 winter season, organic soil amendments for soil-borne disease management in cabbage were tested in Comilla and Rangpur. In all the tests the technology proved very effective producing high economic returns. Tests for fruit fly control in cucurbit crops through bait trapping are continuing in three districts.

**i.** **Projected Outputs:** The results from this study will be helpful for scientists working in the field of IPM and this will also help the extension workers and policy makers.

**j.** **Impacts:** This activity has a broad-based and long-term effect on the production of economically profitable, healthy vegetables and create opportunities for export market.

**k.** **Projected start:** October 2001

**l.** **Projected completion:** September 2004

**m.** **Projected person-months of scientist time:** 6 man-months

**n.** **Budget:** BARI – $ 5,170

**INTEGRATED PEST MANAGEMENT -- COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), ASIAN SITE IN BANGLADESH***

| ACTIVITY | | SCIENTISTS | BUDGET ($) |
|---|---|---|---|
| **BASELINE SURVEY AND CROP/PSET MONITORING** | | | |
| I.1 | Survey of Infestation Levels of White Fly, *Bemisia tabaci*, on Different Vegetable Crops | S.N. Alam, M. Khorsheduzzaman - BARI; A.N.M.R. Karim, H.S. Jasmine - IPM CRSP; E. Rajotte - Penn State; Greg Luther - Virginia Tech | BARI $ 1,760<br>Penn State $64,827<br>AVRDC $ 5,005 |
| I.2 | Survey and Population of Bean Pod Borer (*Maruca testulalis*), Whitefly and Aphids and their Natural Enemies on Country Bean (*Lablab purpureus)* | M. Mozammel Hoque, S.M. Monowar Hossain, Salim Reza Mollik, M. Nazim Uddin, S.N. Alam, M. Khorsheduzzaman - BARI; Mahbubur Rahman - IPM CRSP; Z. Alam - BSMRAU; E. Rajotte - Penn State; G. Luther - Virginia Tech | BARI $ 5,500 |
| **MULTIDISCIPLINARY ON-FARM PEST MANAGEMENT EXPERIMENTS** | | | |
| II.1 a. | Varietal Screening of Eggplant for Resistance to Bacterial Wilt, Fruit and Shoot Borer, Leafhopper (jassids) and Root-Knot Nematode and of Tomato for Resistance to Bacterial Wilt, Virus Disease and Root-Knot Nematode | M.A. Rashid, Shahabuddin Ahmed, M.A. Rahman, Motiar Rahman, M.A. Gaffar, S.N. Alam, M.H. Rashid, M.I. Faruk - BARI; H.S. Jasmine, Nazneen A. Sultana, Baha Uddin Ahmed - IPM CRSP; L. Black, J.F. Wang, N.S. Talekar - AVRDC; G. Luther - Virginia Tech | BARI $ 2,970<br>Ohio State $27,405 |
| II.1 b. | Pilot Production of Grafted Eggplants at Two Intensive Growing Areas (Jessore and Sripur-Gazipur) and Training of Farmers and Nurserymen | M.A. Rashid, Shahabuddin Ahmed, Ataur Rahaman - BARI; M. Rafiquddin - RARS, BARI (Jessore); Baha Uddin Ahmed - IPM CRSP; G. Luther - Virginia Tech; L. Black – AVRDC | BARI $ 4,070<br>Ohio State $ 2,520 |
| II.1 c. | Development of Eggplant Hybrids Resistant to Bacterial Wilt, FSB and RKN | M.A. Rashid, Shahabuddin Ahmed, Ataur Rahaman - BARI; H.S. Jasmine, Nazneed A. Sultana - IPM CRSP; G. Luther - Virginia Tech; L. Black, J.F. Wang – AVRDC | BARI $ 2,200<br>Ohio State $ 1,890 |

| | | | | |
|---|---|---|---|---|
| II.1 d. | Screening of pumpkin germplasm against Watermelon Mosaic 2 Potty Virus (WM2V) | M.A. Rashid, M.A.T. Masud, M.H. Rashid - BARI; M.A. Mannan Akand - BSMRAU; Nazneen A. Sultana, Baha Uddin Ahmed - IPM CRSP; G. Luther - Virginia Tech; L. Black, J.F. Wang - AVRDC | BARI | $ 2,200 |
| II.1 e. | Screening of Okra Germplasm against Yellow Vein Mosaic Virus (YVMV) | M.A. Rashid, M.A.T. Masud, Shahabuddin Ahmed, H. Rashid - HRC (BARI), Md. Hossain - TCRC (BARI), Salim Uddin - Plant Breeding, BARI; Baha Uuddin Ahmed, Nazneen A. Sulatana - IPM CRSP; Sally Miller - Ohio State | BARI | $ 2,200 |
| II.2 a. | Management of Lepidopteran Pests in Cabbage Using an Integrated Approach | S.M. Monowar Hossain, Salim Reza Mollik, M. Nazimuddin, S.N. Alam - BSMRAU; N.S. Talekar - AVRDC; E. Rajotte - Penn State; G. Luther - Virginia Tech | BARI<br>VA Tech | $ 3,630<br>$ 1,270 |
| II.2 b. | Assessment of Virus Infestation at Different States of Okra Plants | S.M. Monowar Hossain, Salim Reza Mollik, M. Nazimuddin, S.N. Alam, M. Khorsheduzzaman - BARI; Mahbubur Rahman - IPM CRSP; Z. Alam - BSMRAU; E. Rajotte - Penn State; G. Luther - Virginia Tech; S. Miller - Ohio State | BARI<br>Ohio State<br>VA Tech | $ 2,200<br>$ 1,890<br>$ 1,270 |
| II.2 c. | Off-season vegetable production under integrated pest management | S.M. Monowar Hossain, Mozammel Hoque, Salim Reza Mollik, M. Nazimuddin, S.N. Alam, M. Khorsheduzzaman - BARI; Baha Uddin Ahmed - IPM CRSP; Z. Alam - BSMRAU; S. Islam - DAE (PPW); E. Rajotte - Penn State; G. Luther - Virginia Tech; L. Black - AVRDC | BARI<br>VA Tech | $ 2,420<br>$ 1,270 |
| II.3 | Patterns and Rates of Fruit Fly (*Bactrocera cucurbitae*) Infestation on Different Cucurbit Vegetables and its Management | M. Nasiruddin, S.N. Alam, M. Khorsheduzzaman - BARI; A.N.M.R. Karim, H.S. Jasmine - IPM CRSP; E.G. Rajotte - Penn State; G. Luther - Virginia Tech | BARI | $ 5,060 |

| | | | | |
|---|---|---|---|---|
| II.4 | Development of an Integrated Management Package for the Control of Eggplant Shoot and Fruit Borer (ESFB) | S.N. Alam, M. Khorsheduzzaman, Sahadat Hossain - BARI; A.N.M.R. Karim, Nazneen A. Sultana - IPM CRSP; E.G. Rajotte - Penn State; G. Luther - Virginia Tech | BARI<br>VA Tech | \$ 3,850<br>\$ 2,540 |
| II.5 | Integrated Management of Weeds and soil-borne Diseases in Eggplant and Tomato | Anwar Karim, S.A. Khan - BARI; A.N.M.R. Karim, Mahbubur Rahman - IPM CRSP; A. Baltazar - NCPC/UPLB; Sally Miller - Ohio State; S.K. DeDatta - Virginia Tech | BARI<br>Ohio State | \$ 2,970<br>\$ 1,260 |
| II.6 | Integrated Management of Soil-Borne Pathogens of Eggplant, Cabbage, Tomato, Pointed gourd and Cucumber in Farmer Fields in Jessore and Gazipur (Sripur) | M.A. Rahman, Khorshed Alam, K.A. Kader, M.I. Faruk - BARI; Haider Hossain - RARS, BARI (Jessore); H.S. Jasmine, Mahbubur Rahman - IPM CRSP; S. Miller - Ohio State; L. Black - AVRDC | BARI | \$ 4,070 |
| **MULTIDISCIPLINARY LABORATORY, GREENHOUSE, AND MICROPLOT EXPERIMENTS** | | | | |
| III.1 | Study of Biology of *Trichogramma* on *Leucinodes* Eggs and *Trathala flavo-orbitalis* on *Leucinodes* Larvae and their Parasitism Efficiency on FSB under Laboratory and Field Conditions | S.N. Alam, M. Khorsheduzzaman, Shahadat Hossain - BARI; A.N.M.R. Karim, Nazneen A. Sultana - IPM CRSP; N.S. Talekar - AVRDC; E. Rajotte - Penn State; G. Luther - Virginia Tech | BARI<br>VA Tech | \$ 2,970<br>\$ 1,270 |
| **SOCIOECONOMIC ANALYSIS** | | | | |
| IV.1 | Measure Economic Impacts of Bangladesh IPM CRSP Research Activities | M.I. Hossain, M.A. Monayem Miah, Nazrul Islam - BARI; H.S. Jasmine, Nazneen A. Sultana, Mahbubur Rahman, Baha Uddin Ahmed - IPM CRSP; G. Shively - Purdue; G. Norton - Virginia Tech | BARI<br>VA Tech<br>Purdue | \$ 1,320<br>\$10,573<br>\$17,261 |
| IV.2 | Socioeconomic Factors Effecting Pest Management Practices and Adoption of Integrated Pest Management Practices in Different Regions of Bangladesh | M.I. Hossain, M.A. Monayem Miah, Nazrul Islam - BARI; Baha Uddin Ahmed, Nazneed A. Sultana - IPM CRSP; C. Sachs - Penn State; G. Shively - Purdue; G. Norton - Virginia Tech; Fakhrul Islam - BSMRAU | BARI<br>VA Tech<br>Purdue | \$ 9,150<br>\$ 3,810<br>\$17,261 |

| | | | | |
|---|---|---|---|---|
| IV.3 | Integration and Diffusion of IPM Technology | M.I. Hossain, S.N. Alam, M.A. Monayem Miah, M. Nazrul Islam, M.A. Rahman - BARI; M. Ataur Rahman - CARE-Bangladesh; Baha Uddin Ahmed, Nazneen A. Sultana - IPM CRSP; G. Shively - Purdue; G. Norton, G. Luther - Virginia Tech; Madonna Casimero - IRRI | BARI | $ 5,170 |

The South Asian Site in Bangladesh also has budgeted funds for the Site Office. This amount totals $81,210 and will be used to complete the activities in the above table.

## Year 10 Workplan for the Caribbean Site – 2002-2003

The research activities of the Caribbean site, centered in Jamaica but extending to other island nations in the region, are conducted under four main components: (1) IPM Systems Development, (2) Pesticide Use and Residues, (3) Social, Economic, Policy and Production System Analyses, (4) Research Enhancement through Participatory Activities.

Primary focus in Year 10 work plan will continue to be on high value, non traditional export crops that are also in demand locally, with the three crops of major focus being hot pepper, sweetpotato, and a high-pesticide-input leafy vegetable crop (with emphasis on crucifers). Essential IPM elements (sampling, monitoring, host-plant resistance, biorational pesticides integrated with resistance management, disease management integrated with insect vector management) are being emphasized in three specific cropping systems where they offer the most rapid gains. These elements are also being integrated within cropping systems (e.g., pest sampling is integrated with use of biorational pesticides and resistance management in leafy and cruciferous vegetables, and pest sampling/monitoring with host-plant resistance and disease management in hot peppers).

Sweetpotato pest management plans involve combining resistant varieties and use of biorationals for grub and weevil control, combined with pheromone and cultural practices for weevil control. This year, the promising new varieties are continuing to be evaluated across the region, and weevil IPM technologies are being disseminated across Jamaica and to other islands. A new project to assess virus incidence in Caribbean varieties will start up in year 10.

Reduced production and productivity of hot peppers due to virus problems has been partially managed through introduction of the virus-tolerant West Indies Red variety to supplement the highly susceptible, but preferred, Scotch Bonnet variety. Management plans to avoid high losses due to early infection of plants are being devised from knowledge of aphid vector activity, and will be tested. Heavy insecticide use in attempts to control virus has increased problems with broad mites and the gall midge complex. Because the latter has been declared a "quarantine pest" by the United States, hot peppers have been removed from the pre-clearance list and fumigation is required. Conditions conducive to gall midge have been identified through surveys and GIS analysis, and areas of low-pest risk may be predicted. Emphasis is now being placed on these pests, including initiation of a regional web/GIS monitoring program.

In leafy vegetable crops, high pesticide use for lepidopteran pests necessitates pesticide residue testing for all processing and export uses. IPM-CRSP-funded research has devised a sampling plan and threshold-based timing of pesticide applications with new selective modes-of-action for reducing this problem. This is being, regionalised and applied to crucifer crops by training farmers throughout the region and conducting field experiments in three island nations (Trinidad, Barbados and Jamaica). Conservation biological control which protects natural enemies under conditions of use of the biorational insecticides in the Caribbean will be measured. Pesticide residue testing will begin using newly–institutionalized, in-country facilities in conjunction with facilities at Ohio State University. The web-based monitoring program that uses a GIS for regional views of pest pressure developed for gall midge IPM will be adapted for monitoring several lepidopterans with pheromone-baited traps.

The program is creating institutional linkages across the Caribbean (such as playing a pivotal role in the PROCICARIBE Caribbean Integrated Pest Management Network (CIPMNET) evolution) and the public and private sector (for web/GIS monitoring and biorational pesticide development which most directly influences safety at the farm level). Research partners are two Caribbean-wide institutions: the Jamaica Unit of the Caribbean Agricultural Research and Development Institute (CARDI), representing the CARDI IPM Centre; and the University of the West Indies – Mona Campus; Natural Products Institute and the Biotechnology Centre; and two Jamaican institutions; the Ministry of Agriculture (MINAG), Jamaica, and the Rural Agricultural Development Authority (RADA) – the extension and training delivery system. In the United States, five institutions participate: Pennsylvania State University in vegetable crop IPM and monitoring programs including web/GIS; Ohio State University in pesticide residue analysis and new insecticides; the USDA's Vegetable Research Laboratory in Charleston SC in sweetpotato breeding and pest management, the University of Californina at Davis in socioeconomic/gender and marketing, and Virginia Tech in virus-vector management and GIS/GPS systems for pest management.

## I. IPM Systems Development

The goal of this section is to develop IPM system components (i.e., sampling systems, decision support tools, and control tactics) and to combine these components into IPMsystems for hot peppers, sweetpotatos, and leafy vegetables. These High value export crops were identified as those in which Caribbean farmers have adopted systems of intensive pesticide application, using chemicals posing high risks to human health and the environment. The Caribbean research team is implementing a phased approach to demonstrate the benefits of decreasing use of these highly toxic materials. The first phase is to demonstrate that the new, biorational selective pesticides can produce comparable crop yields with smaller environmental and human costs and that they must be developed within a resistance management framework. The second and most important phase is to develop and implement IPM systems that are biologically intensive and environmentally benign. Regional monitoring, as an IPM systems component, is being integrated across cropping systems. Several components of hot pepper pest management have been developed separately, but these require integration across several pests for sustainable pepper production. Individual continuing and new projects follow.

### I.1 Threshold-based Management of Pests Affecting Leafy Vegetables with High Pesticide Input

a. **Scientists:** Dionne Clarke-Harris – CARDI; Phillip Chung – RADA; Shelby Fleischer – Penn State Univ.

b. **Status:** Continuing activity, with new activities.

c. **Objectives:**

<u>Overall</u>: (1) To regionalise the IPM systems approach for high-pesticide-input vegetable systems.

<u>Specific</u>: (1) Determine major pests, develop sampling protocols, and monitor populations of major lepidopterous pests on cabbage in three island nations; (2) Evaluate

biorationals on major lepidoptera on cabbage in three island nations; (3) Determine the rate of conservation of biological control.

**d.** **Hypotheses:** (1) Lepidoptera species are major limiting pests on cabbage and leafy vegetables; spatial and temporal distribution of these lepidopterous pests on cabbage have specific sampling requirements and populations of lepidoptera species on cabbage fluctuate throughout the growing season; (2) New biorational pesticides which were effective against lepidoptera on callaloo will have similar efficacy against major lepidoptera species on cabbage and other crucifers; (3) Conservation of predators and parasitoids result in significant lepidopteran pest control in cabbage, and that these natural enemies can be conserved when biorational /microbial pesticides are used and timed well with sampling protocols; (4) Regional monitoring will help alert pest managers and help facilitate field-scale monitoring, and web, GIS, and pheromone technologies can be adapted to monitor lepidopteran pests over regional scales; and (5) Training of Caribbean scientists in biological control in cabbage and in the integration of pheromone, web, and GIS technologies for pest monitoring will facilitate IPM in leafy vegetables and be transferable to IPM in other crops.

**e.** **Description of research activity:**

**Jamaica**

**(1) Development of sampling protocols and population monitoring for major lepidoptera species on cabbage in the Caribbean.**

Monitoring surveys will be conducted in Trinidad, Barbados, and Jamaica to record the incidence and economic importance of major pests on crucifers under varying management programs, including programs that use biorational and microbial pesticides.

The sampling protocol will be developed based on within-plant and within-field distribution of the pests initially using methods currently accepted in the north-eastern US.

**(2) Evaluate biorationals, thresholds, and exclusion on major lepidoptera on cabbage.**

The efficacy of two biorational pesticides (an insect growth regulator and a microbial metabolite), applied with and without threshold-based decision rules will be evaluated in randomised complete block experiments in Trinidad, Barbados and Jamaica. Research collaborators will have been identified from Barbados and Trinidad during regionalisation training workshops conducted in Year 9.

**(3) Conservation biological control in cabbage**

Rates of parasitization of lepidopteran larvae and pupae in plots treated with microbial and biorational pesticides, and with grower standards and untreated controls, will be compared.

**(4) Monitor lepidopteran pest pressure at a regional scale using web-GIS**

Traps baited with pheromones for lepidopteran pests (including diamondback moth, fall armyworm, and beet armyworm) will be established at multiple sites in Jamaica. Traps will be serviced weekly. The web –GIS program being established for gall midge, which can accommodate multiple pest species, will be adapted and used to track the dynamics of these lepidopterans over wide scales in Jamaica and other Caribbean countries.

**(5) Train Caribbean researchers in biological control in cabbage agroecosystems and web-GIS monitoring with pheromone traps.**
Researchers will attend an international conference on biological control in cabbage. The integration of using pheromone, web and GIS technology to monitor pest populations will be taught to pest management scientists in 3 Caribbean island nations, and software provided.

**f. Justification:** Synthetic chemicals currently used for lepidopteran pest control are resulting in crop failures, and the development of pesticide resistance is highly probable based on results of initial bioassays conducted in Year 5 and surveys of pest management scientists in the Caribbean regions. New biorational pesticides either already have, or are rapidly gaining, EPA registrations in leafy vegetable or cruciferous crops in the United States. They have novel modes-of-action that were effective against lepidopteran larvae in the Caribbean which were not being controlled by carbamates, phosphates or pyrethroids. Maintaining registrations on biorationals is more feasible and they improve farm-worker safety.

IPM CRSP research conducted in Jamaica (primary site) focused on addressing the problem of excessive pesticide use on a leafy vegetable (amaranth) grown for the local and export market. The resulting IPM strategy, based on rationalised pesticide use, resistance management the use of new, selective, biorational and botanical pesticides has been successful on vegetable amaranth (callaloo in Jamaica, and is applicable to other vegetable systems with high pesticide input. One non-chemical management tactic, pest exclusion, has also shown potential for IPM.

The crucifers have been identified as a leafy vegetable system, grown universally in the Caribbean and plagued with pest and pest management problems similar to those of the vegetable amaranth studied in Jamaica. From among the 16 member countries of the Caribbean IPM Network, which participated in a priority setting exercise, 11 listed the diamond-back moth on cabbage as a priority pest management issue of their country. The implementation of an effective IPM strategy for this crop would therefore have far-reaching impact within the Caribbean Region. Training in the IPM systems components against lepidopteran pests of leafy vegetables in the Caribbean region was part of Year 9. In Year 10, we will conduct the field experiments that will test these IPM components in crucifers across the Caribbean region.

Several lepidopteran species lend themselves well to monitoring with pheromone traps. Pheromone based monitoring help to time biorational pesticide application, and trap catch densities have shown correlation with larval densities in amaranth in Jamaica. Accordingly, we will implement the use of pheromone traps as part of the pest monitoring program in leafy vegetables, resulting in time-series data of pheromone trap catch. Time-series data can readily be geo-referenced, input into databases via the web, and displayed via the web. The Caribbean site is developing this technical capability as an IPM systems component for dealing with the gall midge in peppers, and this component easily translates across cropping systems. Progress in this represents development of technical infrastructure for IPM implementation. It is more easily developed with pheromone trap sampling methods, and thus can begin to be developed across the Caribbean region.

The newer biorational materials may result in significant conservation of natural enemies when deployed at a farm scale, and biological control is often an important IPM systems component in crucifer crops. Training of Caribbean scientists in biological control in crucifers will enable them to incorporate this component into this agroecosystem. Training in the web-GIS technologies will facilitate its expansion into other Caribbean nations.

g. **Relationship to other CRSP activities at the site**: The main thrust is geared towards validation and implementation of the IPM model developed for rationalized pesticide use in management of lepidopteran pests on leafy vegetables, and is a focus of regionalisation activities. IPM systems development on all commodities (hot pepper, leafy vegetables and sweetpotato) is now at the regionalisation phase. These activities are promoting all the developed strategies to the various groups of farmers and other agriculturists targeted during training sessions. These groups would therefore be exposed to IPM in its broadest sense as the strategies developed for each commodity has a different focus based on the principles of IPM.

h. **Progress to date:** During Years 1-6 high levels of damage by lepidopteran pests have been documented in spite of pyrethroid applications, and completed bioassays from field-collected larvae using methods modified for local situations. Together, the results show a strong probability that populations are resistant to λ-cyhalothrin. Small plot trials continue to demonstrate dramatic increases in management of lepidopterans on vegetable amaranth with new biorational chemistries (two microbial metabolites - spinosad, and emamectin benzoate; and one insect ecdysone agonist –tebufenozide (Confirm®). Earlier studies with Bt in callaloo, where *Spodoptera* spp. were important, were not effective. We anticipate similar results in cabbage, but with the increases use of Bt as a microbial pesticide (using the *aizaiwa* strain as needed), and possibly the replacement of the newer ecdysone agonist with the newer formulation (Intreprid®). We also gained experience with cultural techniques (exclusion with agricultural mesh fabrics), which have been effective in callaloo, and we anticipate increased efficacy in cabbage using floating row covers for a single harvest. The new biorationals were introduced at the farm level in the latter part of Year 7 and results will be used in conjunction with resistance management techniques (sampling plan and decision making tool) and pesticide rotations. The development of pest exclusion as a management tactic progressed with the selection of a barrier material, which would allow optimal growth, and development of the crop and the system is being evaluated on farm.

Monitoring with pheromone traps had been completed for several lepidopteran pests in Jamaica, and adult trap-catch densities were correlated highly with in-field whole plant searches of immature life stages. Installation of web-GIS software and integration of using that across governmental agencies (RADA and CARDI), has been progressing as part of the gall midge project and can be readily adapted to leafy vegetable systems

i. **Projected outputs:** (1) A system to effect rationalised pesticide use against lepidopterous pests of cabbage. (2) IPM researchers trained in a research approach to IPM system development (3). An understanding of the natural enemies currently present in lepidopteran pests of cabbage in the Caribbean. (4) Initiation of a regional monitoring effort for lepidopterans.

**j.** **Projected impacts:** The successful development of a crop-scouting program integrated with the use of biorational controls will result in much fewer pesticide applications, which represents a very significant reduction in labor for these growers. This work will result in a gradual transition to biorational pesticide control options, with enhanced farm worker safety and reduced food safety concerns due to pesticide residues, as well as a reduction in pesticides that are targeted by the Food Quality Protection Act in the US. There will also occur enhanced efficacy of control because the biorationals use modes-of-action which are new to the pest complex in the Caribbean. The integration of the biorationals with the scouting will delay or prevent the development of pesticide resistance to the new materials.

Our previous efforts represent pioneer work in vegetable IPM in the Caribbean, and because of the polyphagous nature of the lepidopteran complex that was addressed on callaloo, the technologies have relevance to other leafy vegetable systems in the Caribbean. The classical nature of this IPM model also makes it applicable to other cropping systems with excessive pesticide use.

Lepidopterous pests attacking cabbage and other crucifers in the Caribbean have exhibited symptoms of pesticide resistance, which is widespread globally. Major pests such as the diamond-back moth now cause severe damage to crops as contemporary pesticides fail to prevent attack. The development of an effective pest management strategy that reduces pesticide input in the cropping systems of cabbage and other crucifers of the Caribbean will result in increased income to farmers, safer food and reduced environmental pollution. From the proposed training, IPM researchers in the Caribbean will also have a research model, which they can apply to the development of IPM for other high-pesticide-input vegetable crops not directly addressed by IPM-CRSP activities.

**k.** **Projected start:** Continuation

**l.** **Projected completion:** September 2003

**m.** **Projected person months of Scientist Time per year:** Scientists, 7 months + Technicians, 7 months (CARDI); 2.0 months (Penn State)

**n.** **Budget:** IPM CRSP: $25,000– CARDI; $6,500 – Penn State; $4,000 - VT
$5,000 - MINAG Barbados; $5,000 - MINAG Trinidad
Other: Personnel Costs– CARDI; Personnel costs – Penn State

## I.2 Integrated Pest Management (IPM) of Major Pests Affecting Sweetpotato in the Caribbean

**a.** **Scientists:** Kathy Dalip, Llewelyn Rhodes, Reginald Andall, Herman Adams - CARDI; Phillip Chung - RADA, D. Michael Jackson, Janice Bohac - USDA.

**b.** **Status:** Continuing Activity

**c.** **Objectives:** (1) Evaluate new IPM techniques for managing soil insect pests; (2) demonstrate and disseminate new IPM technology, including new resistant varieties; and

(3) regionalize IPM technology to selected countries in the Caribbean through research, demonstration, and training.

d. **Hypotheses:** (1) Biologically-based pest control techniques (use of pheromones and kairomones, insect growth regulators, entomopathogens, botanical compounds) are potential IPM tactics for reducing damage from sweetpotato weevil, sweetpotato leaf beetle, and other insect pests of sweetpotato. (2) Differential response to pest attack exists in sweetpotato germplasm, which can be used for development of pest-resistant cultivars (USDA and Caribbean sources). (3) Host plant resistance, biologically-based control techniques, and improved cultural measures can be used as components of IPM programs to control pests and diseases and lessen the impact of chemical insecticides throughout the Caribbean region.

e. **Description of Research Activity:**

**USA** (J. Bohac & D.M. Jackson)

**(1)** Efforts will continue at the U. S. Vegetable Laboratory to develop dry-fleshed sweetpotato breeding lines with multiple pest resistance for introduction into the Caribbean. Greenhouse tests and laboratory bioassays will be conducted to evaluate breeding lines for resistance to insects, root-knot nematodes, and *Fusarium* wilt. Selected breeding lines will be evaluated in field tests for insect resistance and yield, quality, and appearance. Improved red-skinned, cream-fleshed sweetpotato clones that are candidates for release as cultivars will be sent to Jamaica and St. Kitts in 2002. To determine the potential acceptability of new sweetpotato genotypes, samples of roots will be evaluated by farmers or consumers for appearance and culinary qualities. Root samples will be tested in the laboratory at CARDI for storability, culinary quality and percent dry matter. New trap designs and lures for monitoring adult sweetpotato weevils and *Diabrotica* spp will be evaluated. USDA collaborators will visit Jamaica and the eastern Caribbean to assist in the evaluation of biologically based management techniques for insect pests of sweetpotato, in the coordination of collections of *Beauveria*-infected sweetpotato weevils, in the collection and analysis of data on insect-resistant germplasm, in the assessment of new insect trapping systems, in the regionalisation of IPM technology in the eastern Caribbean, and in the development of value-added products for Caribbean consumers.

**Jamaica** (J. Bohac, D.M. Jackson, L. Jackai, P. Chung & K.M. Dalip)

**(1) Evaluation of the efficacy of selective synthetic insecticides, an insect growth regulator (imidacloprid, Mach 2®), botanical (garlic repellent) and resistant cultivars (Picadito, Fire-on-Land, PI531116 and TIS 30-30) to reduce weevil and grub populations**. The crop will be grown in two different sweetpotato-growing parishes using agronomic practices currently employed by farmers. Treatments will be allocated in a randomized complete block with 4 replicates, 50 plants per treatment. A susceptible cultivar will also be included in the trial for comparison with the resistant varieties. Parameters measured will include: pest incidence (pre- and post- treatments) and crown/root damage

**(2) Identification of USDA and Jamaican sweetpotato cultivars with desired characteristics for release to farmers.** The most promising USDA cultivars, PIs (plant introductions) and Jamaican varieties with acceptable characteristics (i.e. dry-fleshed, red-skinned sweetpotato cultivars with multiple pest resistance), identified from past trials will be used in trials to confirm/verify their tolerance to the pests under different conditions (present) in three parishes. The recommended management practices developed under the project (including the improved pheromone trap design) will also be employed. Lines will be evaluated for insect resistance (especially for sweetpotato weevil), yields and marketable criteria. Insect resistance will be measured by scoring with a rating scale developed under the project. Samples of the selected cultivars will be given to farmers or consumers for assessment of appearance and culinary qualities of roots.

**(3) Demonstration and Training in Sweetpotato IPM Technology.** Sweetpotato weevil IPM technology (cultural practices and pheromones), developed during the past four years in Jamaica, will continue to be disseminated to other parts of the island and to selected countries in the Caribbean. In Jamaica, demonstration and training regionally will continue to focus on sweetpotato weevil and sweetpotato leaf beetle. Three demonstration farms will be established using the typical agronomic practices utilized by farmers in the selected parishes along with paired plots on which all recommended IPM practices are employed. At harvest, the effect of the introduced technology on weevil population, root damage and improvement in marketable yields will be measured. Weevil infestation levels will be determined with traps baited with low doses of pheromone and crop loss assessments executed at harvest. These demonstration farms will be used to disseminate the technology to farmers within the production areas using the modified farmer field school approach utilized in Jamaica. Prior to the introduction of the technology within any production area, baseline information on production and marketing systems and economic status of the weevil and other sweetpotato pests will be collected.

**(4) Follow-up reassessment of IPM systems on the yield and quality of sweetpotato production.** Surveys will be conducted in parishes/areas where training of farmers and extension officers were carried out to determine the level of adoption of the IPM technology; this will include a "post-project" survey of growers' practices and attitudes. On-farm assessments of yields will also be carried out on selected sweetpotato farms these areas to determine the extent of crop loss to the weevil and grub in order to compare with figures obtained earlier in the project. The marketing of the tubers will also be assessed to determine if there have been any modifications in marketing practices.

**(5) Evaluation of attractant traps for monitoring *Diabrotica* spp. and/or *Typophorus viridicyaneus*.** Various proprietary attractants (obtained from a commercial vendor) will be identified that may be attractive to cucumber and sweetpotato leaf beetles. These attractants will be investigated at two sites for their efficacy in attracting these pests placing in traps and determining the number of pests caught. The optimal placement of the traps in the field will also be investigated.

**(6) Collection of weevils for comparison of the genetic diversity of different sweetpotato weevil populations.** Sweetpotato weevils will be collected from the different sweetpotato-growing parishes across the island. The specimens will be taken back to Alabama, USA where they will be extracted and analysed for DNA in order to compare with other weevil populations from the USA and in selected locations in the world .

**St Kitts and Nevis** (D.M. Jackson, L. Rhodes, H. Adams & K.M. Dalip)

**(1) Evaluation of Potential USDA and OECS Sweetpotato Varieties for Yield, Market Acceptance and Insect Resistance.** On each island, USDA and OECS (Organisation of Eastern Caribbean Countries) sweetpotato lines will be evaluated for insect (especially for sweetpotato weevil) resistance, yields and marketable criteria. The lines will be assessed using methods described for Jamaica, and Dr. Jackson will visit the site to assist cooperators in evaluation of lines and analysis of data. Additional red-skinned, cream-fleshed sweetpotato clones that are candidates for release as cultivars will be sent to Jamaica, St. Kitts, and other Caribbean locations in 2002.
**(2) Demonstration and Training in Sweetpotato IPM Technology**. This will be continued in St Kitts and Nevis (see methodology for Jamaica). There will be an increase in the numbers and geographical range of farmers with whom we are working on both islands.
**(3) Development of value-added products.** The screening of different varieties grown on the island will be carried out to identify varieties with characteristics suited for processing eg., to make chips.
**(4) Publication of compilation of recipes.** The preparation of a compilation of recipes from the region in a publication can further fuel the interest already being created in the development of value-added products. Sourcing of recipes from the region will be done through literature searches, which can be facilitated through the different networks under PROCICARIBE and CARDI.

**Montserrat** (D.M. Jackson, L. Rhodes & K.M. Dalip)
**(1) Demonstration and Training in Sweetpotato IPM Technology**. Sweetpotato weevil IPM technology (cultural practices and phermones), developed in Jamaica over the past four years, will continue to be disseminated to selected countries in the Caribbean, including Montserrat, which has not yet been exposed to this technology. The training of Ministry personnel and farmers will be included as a part of the expansion of the regionalization of the technology.

**St Vincent** (A. Lagnaoui, D.M. Jackson, R. Andall, S. Edwards & K.M. Dalip)
**(1) Evaluation of Sweetpotato Cultivars for Yield, Market Acceptance and Insect Resistance.** Sweetpotato lines that are already present in the country will be evaluated at harvest for the following characteristics: insect resistance, yields, marketable grades and storage qualities of tubers. The cultivars will be assessed using methods described for Jamaica.
**(2) Assessment of IPM technology in reducing damage due to *Euscepes postfasciatus*.** The IPM technology developed in Jamaica will be evaluated in a small pilot test consisting of five farms using our best IPM practices and five farms using traditional production techniques. At harvest, the effect of the introduced technology on the West Indian sweetpotato weevil (*Euscepes postfasciatus*) population, root damage and improvement in marketable yields will be measured. Strains of *Beauveria bassiana* will be evaluated for efficacy on *E. postfasciatus*. This work will be done in cooperation with Aziz Lagnaoui (CIP, Lima, Peru).
**(3) Collection of *Beauveria*-infected weevils.** A survey will be done across the island to determine whether *B. bassiana* is already present and affecting WI sweetpotato weevil in different parts of the island.

**f.** **Background/ Justification:** During the past four years the major focus of the sweetpotato research has been the evaluation of cultural practices, pheromones and resistant varieties to manage sweetpotato weevil populations. The development of a soil grub, *Typophorous viridicyaneus* (Coleoptera: Chrysomelidae), as a major limiting pest has highlighted the need to identify and evaluate other management options which are cross-cutting in nature, i.e. they have the potential to reduce both weevil and sweetpotato leaf beetle larvae populations and damage. These new technologies are especially important in Caribbean nations that have these pests present. Biorationals, such as insect growth regulators, have been shown to be effective against coleopteran beetles under crops similar to those present in Jamaica these are therefore to be evaluated as adjuncts to the IPM being developed.

As in Jamaica, the sweetpotato weevil limits sweetpotato production in several islands in the Caribbean. The sweetpotato weevil IPM technology that was being developed and evaluated in Jamaica should be able to assist in improving marketable yields of sweetpotato in islands presently experiencing the problem. However, before large-scale introduction of this technology is attempted it is critical that evaluations are conducted under the various agroecologies and cropping regimes of other islands. This will assist in refining the IPM technology to suit the production systems present in other islands as well as identifying socioeconomic factors that may impede the adoption of the technology. After this information is available, comparisons can be made on the extent to which technologies can be transferred across agroecosystems.

**g.** **Relationship to other IPM-CRSP activities at the site:** The overall purpose of the research activities proposed above is to identify pest control methodologies that can be used as components of integrated pest management programs for controlling pests of sweetpotato in the Caribbean. The activities conducted will assist greatly in improving the options available to farmers for weevil and grub management. Previous research at the U. S. Vegetable Laboratory suggests that host plant resistance in sweetpotato to insects, root-knot nematodes, and *Fusarium* wilt is a viable and logical approach for IPM of sweetpotato pests in the Caribbean. In addition, the work is targeted to achieve regionalisation of the IPM CRSP programme within the Caribbean.

**h.** **Progress to date:** In year 9 in Jamaica, the evaluation of yield and insect resistance traits of select USDA Jamaican sweetpotato varieties revealed that the following varieties may be included in IPM technology: TIS30-30, Fire-on-Land, White Regal, PI531116, Sidges, W-341 and Picadito.

In the US, significant progress was made in developing high yielding, multi-pest resistant, red-skinned, white-fleshed sweetpotato clones. Seven USDA cultivars were sent to Jamaica from USDA, South Carolina and evaluated in varietal trials.

Training workshops were held in St Elizabeth in Jamaica. Twenty-five sweetpotato extension officers were trained in the sweetpotato weevil IPM technology. One field day was held in St Elizabeth to demonstrate mainly the use of the pheromone traps in a sweetpotato plot.

**St Kitts & Nevis**

The assessment of yield and insect resistance traits of select USDA Jamaican sweetpotato varieties indicated that the local varieties showed greater tolerance to sweetpotato weevil damage than USDA varieties. However, the tolerance to white grub by two USDA varieties was equal to or better than the local varieties. Varietal trials were repeated in March 2002. As part of the demonstration and training in sweetpotato IPM technologies, two farms were used and pheromone traps made and maintained for the duration of the crop. Weekly catches of weevils were recorded to demonstrate the effectiveness of the trap.

**St Vincent**

The identification of varieties (present locally) to be compared was done but the trials could not be completed as the necessary personnel were not in place to supervise the activities. Plans to initiate the survey to determine the presence of *Cylas formicarius* had been put in place but the survey was not started. Once the personnel positions have been filled, the surveys will be carried out.

**i.** **Projected outputs:** (1) Improved capability to forecast pest incidence and recommend IPM strategies for the research crops. (2) Increased tactics available for IPM package improving sweetpotato production. (3) Development of pest resistant sweetpotato cultivars that are suitable for commercial production in the U.S.A. and the Caribbean. (4) Technology Package - fact sheet series.

**j.** **Projected impacts:** The research activities will improve sweetpotato production systems and ultimately the quality and quantity of marketable produce in the USA and the Caribbean. In addition, the use of IPM programs to manage the pests will lessen the dependence on pesticides, thus reducing environmental pollution and risks to human health, and slowing down development of resistance.

**k.** **Projected start:** Continuation

**l.** **Projected completion:** September 30, 2003

**m.** **Projected person-months of scientist time per year:** 1

**n.** **Budget:** IPM CRSP: $15,397 – CARDI: St Kitts and Nevis $2,050; Montserrat $500; St Vincent and the Grenadines $3,823; Jamaica $11,410
Other: personnel costs- CARDI, OSU, USDA (Scientist's time)

## I.3 Assessment of Virus Incidence in Superior Caribbean Sweetpotato Varieties

**a.** **Scientists:** Kathy M Dalip - CARDI; D. Michael Jackson, Janice Bohac - USDA-ARS Vegetable Laboratory; Sue Tolin - Virginia Tech.

**b.** **Status:** Continuing Activity

**c.** **Overall Objective**: Consistent with development of sweetpotato IPM, new varieties with excellent resistance to insects have been identified from among varieties grown locally in Jamaica. The objective of this activity is to assess the status of these varieties relative to virus infection, and to eliminate those viruses decreasing sweet potato performance from the germplasm.

**Objective for coming year**: Determine the status of Jamaican sweet potato varieties relative to natural infection with common sweet potato viruses, using available technology from U.S. and international (CIP) testing programs.

**d.** **Hypotheses:** (1) Local varieties are likely to carry a background of common sweet potato viruses, most likely sweet potato feathery mottle virus, and are causing unrecognized yield losses or changes in reactivity with other organisms. (2) Viruses may be eliminated from varieties and improve their yield and productivity.

**e.** **Description of research activity:** Information will be collected on the availability of rapid virus identification tests for the common sweetpotato viruses. Purchase antiserum or virus-testing kits, and train CARDI researchers in methodologies of sampling and testing for viruses. Specifically, we will test the varieties that have been shown to perform well and resist major insect pests. Jamaican varieties which may be included, based on their resistance to insect pests are: Sidges, Fire-on-Land and Quarter Million.

Observations will be made of sweetpotato performance and symptoms (of foliage and roots since sweetpotato roots can also show symptoms of some of these viruses) associated with the main viruses that are detected. The need for a virus detection program in the propagation of sweetpotato mother plants will be assessed and whether selection of plants free of damaging viruses for distribution to farmers will increase sustainability.

**f.** **Background/Justification:** Worldwide, viruses have been shown to have effects on the yield and productivity of sweetpotato. Major viruses include sweetpotato feathery mottle virus strains. There is currently no knowledge of the virus status of the local Jamaican varieties. Although no viruses have been recognized as present and decreasing yields of sweet potatoes, foliar symptoms have been observed in several fields.

**g.** **Relationship to other CRSP activities at the site:** Sweetpotato has been a crop examined in the IPM-CRSP since the beginning of the project. IPM strategies have been developed and implemented for sweetpotato weevil and soil grubs. Superior varieties have been identified. Elimination of viruses from these varieties will complement this activity.

**h.** **Progress to date:** A few sweetpotato varieties grown in Jamaica have been identified from past varietal trials as having desirable insect resistant and/or yield characteristics.

**i.** **Projected output:** Information on the incidence of sweetpotato viruses in Jamaican varieties and their impact on yield.

**j.** **Projected impacts:** An incremental improvement in yield of sweet potato of varieties well-adapted to the region. An understanding as to whether presence of virus influences attack/damage by other pests.

**k.** **Projected start:** September 30, 2001

**l.** **Projected completion:** (indicate month and year): September 29, 2003.

**m.** **Projected person-months of scientists time per year:** 2 months

**n.** **Budget:** Carry-over from Year 9.

## I.4 Integrated Pest Management (IPM) of Pests Affecting Hot Pepper (Scotch Bonnet and West Indian Varieties)

**a. Scientists:** Francis Asiedu, Dionne Clarke-Harris**,** Kathy Dalip, – CARDI; Timon Williamson, Juliet Goldsmith – MINAG; Clive A. Edwards, Matt Schroeder (Graduate Student) – OSU; Phillip Chung – RADA; Wayne McLaughlin – U.W.I.; Sue Tolin – Virginia Tech.

**b. Status:** Continuing and New Activities

**c. Objectives:** (1) Characterise Jamaican isolates of tobacco etch virus (TEV from selected hot pepper fields; (2) Determine the relative efficiencies of *Aphis gossypii, A. amaranthi* and *Uroleucon ambrosia* in transmitting TEV and PVY to pepper; (3) Evaluate the efficiencies of various methods of weed management in managing TEV (and PVY); (4) Validate a risk management model for reducing TEV (and PVY) in hot pepper in the Bushy Park/Bodles areas of St. Catherine; (5) Develop alternate strategies, such as induced systemic resistance or resistance developed through breeding and genetic engineering to control TEV on hot pepper; (6) To continue training of CARDI/MINAG scientists in the taxonomy of broad mite predators; (7) To test abamectin and diafenthurion, which gave good results in Year 9, in a second season and to test other biorationals and low environmental impact acaricides, for effects on broad mite and natural enemy populations; (8) To continue studies on the relative incidence of broad mite and its predators in sprayed and unsprayed fields and during dry and wet weather. To finalize identification of those pesticides least toxic to natural enemies of broad mites; (9) To determine thresholds for use of acaricides to control broad mites; (10) To develop ratings of broad mite damage that could be used by farmers to initiate control measures (11) Determine thresholds for pesticide control; (12) Develop a multi-pest integrated pest management system for hot peppers.

**d. Hypotheses:** (1) TEV in Jamaican hot peppers are identical to previously described and sequenced type isolates of TEV; (2) *A. gossypii, A. amaranthi* and *U. ambrosiae* are all efficient in transmitting TEV and PVY from pepper to pepper; (3) Effective weed management can significantly reduce the build up of TEV (and PVY) inocula and/or their aphid vectors thereby reducing the spread of these viruses to hot pepper; (4) Farmers can reduce and delay the spread of TEV (and PVY) in hot pepper by employing various combinations of risk reducing tactics in an integrated management program; (5) Hot peppers with greater resistance to TEV can be developed; (6) Biorational acaricides with a narrow spectrum of activity used with a threshold population will minimize damage to natural enemies and control broad mite better; (7) Increased attacks by broad mite in recent years are due to suppression of natural enemies by acaricides and insecticides; (8) A rating assessment of damage criteria will facilitate use of control measures.

**e. Description of Research Activities:**

**(1) Characterization of Virus Complex.** To validate the hot pepper virus and vector management work, it is appropriate to confirm the identity and examine molecular diversity of the Jamaican isolates from the "type" strains of potyviruses. Virus-infected hot peppers will be collected from the location of previous test sites in Kingston (CARDI, Mona), St. Catherine (Bushy Park and Bodles), and St. Mary parishes in an attempt to collect representative isolates of TEV and PVY, as detected by serological methods.

Viruses will be cultured in hot peppers or tobacco in Jamaica. Molecular biological methods, including RT-PCR and nucleotide sequencing, will be used to examine coat protein and 3' untranslated regions which are known to be important in virus classification and demonstration of diversity. Sequencing will be performed at U.W.I. or Virginia Tech, and analyses done by standard methods.

**(2) Vector efficiencies of three selected aphid species.** *A. gossypii, A. amaranthi* and *U. ambrosiae* are the most common aphid species collected in pan traps from hot pepper farms. The former is a known vector of TEV but while the latter two have not been tested for their ability to transmit TEV, their presence has been associated with the incidence of the virus. The aphids will be reared on pepper, callaloo and whitetop, respectively. Non-viruliferous aphids will be allowed to make short acquisition probes (15-60 seconds) on virus infected pepper plants before being transferred to uninfected pepper plants. Transferred aphids will be allowed to remain on these uninfected plants for 24 hours after which they will be killed. Inoculated plants will be assessed for symptom development and the virus will be confirmed serologically.

**(3) Weed and Aphid Management to Manage Viruses.** Weeds are a major constraint in hot pepper production. The lack of expertise in weed management in the Caribbean region has been a major impediment to the development of technology in this discipline. One weed in particular hosts an aphid whose population was correlated with increased infection of Scotch Bonnet peppers with TEV. Replicated field experiments will be initiated to evaluate efficacy and cost effectiveness of a chemical herbicide, manual weeding, organic mulch and managed ground cover. Treatments will be allocated in a randomized complete block design with four blocks, four treatments and 50 plants per treatment (n = 800). Blocks will be separated by corn barriers. Parameters measured will include percentage virus incidence, aphid abundance, yield and quality of fruit, cost of production. Virus incidence will be measured fortnightly throughout the course of the experiment. Aphid abundance will be measured with yellow sticky traps or water traps. Yield data (total and marketable fresh weight of fruit) will be measured from the innermost row of pepper plants as well as the entire treatment unit over five to eight weekly harvests. Appropriateness of low input applicators will be evaluated.

**(4) Establishing risk indices for various components of a model for managing aphid-borne pepper viruses.** As part of her dissertation, one of our graduate students proposed a risk management model for reducing the incidence and impact of TEV (and PVY) in hot pepper. The relative risk-reducing indices were subjective and need to be determined scientifically. The proposed model was a modification of that developed for management of tomato spotted wilt virus (TSWV) in peanuts in Georgia (Brown[1] *et al* 2001). The tomato spotted wilt virus risk index has proven successful in Georgia where farmers have adopted it. A risk management model for TEV holds promises for Jamaica where production of the preferred, Scotch Bonnet, variety is severely limited by the virus. Model components for reducing risks of TEV and (PVY) infections include application of stylet oil, reflective mulch, straw mulch, barrier crops, weed management, removal of old crops and other vector/virus sources, and modification of planting dates. It was proposed that risk indices would be developed in year 9 for model which include

[1] Tomato Spotted Wilt of Peanut - Identifying & Avoiding High Risk Situations. Brown, S., J. Todd, A. Culbreath, J. Baldwin, J. Beasley, B. Kemerait and H. Pappu. 2001. University of Georgia College of Agricultural & Environmental Sciences/Cooperative Extension Service Bulletin 1165/Revised February, 2001

application of stylet oil, reflective mulch, straw mulch, and combinations of stylet oil and aluminum and straw mulches. However this experiment will be deferred to year 10. Six treatments will be allocated in a randomized complete block design with three blocks and 40 plants per treatment (n = 720). The control will lack use of oil and mulch. The experiment will be conducted during September-February to account for the period of high aphid abundance and during June to November to account for low aphid abundance during the early growth phase of the crops. Parameters to be measured will include aphid abundance, virus incidence, broad mite incidence, fruit yield and quality, cost of production.

**(6) Broad mite and predator population.** The method of sampling and recovering broad mite populations, using hot water, was successful for broad mites but did not recover sufficient natural enemies for a valid statistical assessment. The method will be supplemented by collecting more leaves per plant and washing these through nested sieves with a high-pressure water jet.

**(7) Training in mite taxonomy**. Training will be continued on identification of mites that are predators of broad mites. One person from CARDI or MINAG will be selected for broader training in mite taxonomy and sent to the International Training course (3weeks) in mite taxonomy, held annually at OSU in late June-early July.

**(8) Effects of biorational pesticides on populations of broad mites and their natural enemies.** Abamectin and diafenthurion which had little effects on natural enemies and were very effective against broad mites in Year 9 will be tested again, together with new ones in Year 10, with the focus not only on broad mite control but particularly on the effects of the pesticides on natural enemies of broad mite. A new fungicide, Trilogy® will be tested alone and in combination with abamectin. The aim is to identify those pesticides with least effects on natural enemies that can be used in an IPM programme

**(9) Development of thresholds for control measures for broad mite:** Studies on broad mites in Year 9 demonstrated clearly that the incidence of broad mite was linked strongly to climatic factors. There is a need to link the size of early broad mite population with the development of damage symptoms through the growing season. This would allow threshold levels for control measures to be developed, taking into account weather predictions. We will study the development of broad mite populations in five fields by sampling leaves from 10 plants and washing mites using methods developed in Year 8. Sampling will be at 2 - 3 weekly intervals. The development of lesions and other symptoms of attack will be followed by scouting plants on the same sampling dates. Data on mite populations and damage will be correlated.

**(10) Use of rating criteria for identification of broad mite damage:** We plan to develop a scale of damage ratings corresponding to clean, mild, moderate and severe damage symptoms that could be used by farmers and to link these with levels of broad mite populations during a range of previous periods.

**(11) Continuation of farm survey on incidence of broad mites:** The comparison between incidence of broad mites on farms not using pesticides and those with frequent spraying will be continued. The data will also be used to assess the effects of dry and wet weather on mite population buildup.

**f. Justification/Background:** Virus infection is so prevalent in hot peppers that the farmers consider it normal. The newly-introduced West Indian Red variety has some tolerance since infected plants grow vigorously and yield prolifically. However, Scotch Bonnet remains the preferred variety because of its superior flavor and the higher price it commands on both export and domestic markets. Its production continues to be diminished by virus. Variety resistance to specific viruses must be a long-range goal that should be initiated. The current activities suggest that a management plan can be devised so the Scotch Bonnet variety can be grown sustainably now. These combined research activities will investigate those factors that promote large broad mite populations, the more important natural enemies of the pest and means of controlling them as components of an IPM strategy.

g. **Relationship to other CRSP activities at the site:** Hot peppers have three major pest problems in Jamaica: virus attack, gall midge and broad mite. We have IPM components in place for all three problems. We now plan an integrated IPM protocol to cover all three pests. As an example, if aphids transmit broad mites, aphid management for virus control would also contribute to broad mite management. The activities conducted will assist greatly in improving the options available to farmers and in addition assist with the regionalization of the IPM CRSP in hot peppers.

h. **Progress to date:** Basic information on the effect of viruses on yield and seasonal incidence of the major pests affecting hot pepper production in three major producing areas has been determined. Experiments have shown that early TEV infection of Scotch Bonnet pepper causes significant losses in yield. Sampling aphids in pepper fields in Bushy Park and Bodles, St. Catherine, for almost two years has shown that peak aphid flights begin during September, shortly after pepper seedlings are transplanted (that is, during stage of greatest yield loss, if infected). Over 30 species of aphids have been collected from within Bushy Park and Bodles, five of which are known vectors of TEV. Twelve species were previously unidentified in Jamaica. Two were associated with increased virus infection times. TEV within field spread occurs by secondary means. Stylet oil and aluminum mulch together have been effective in delaying the spread of viruses in the field under heavy virus pressure. Weekly application of stylet oil to manage TEV appeared to also have reduced broad mite incidence in treated plots. In Year 8 and 9, it was demonstrated that those farmers that used most pesticides had the highest incidence of broad mite. This has focussed on a need for identification of pesticides that have least effects on populations of the natural enemies of broad mite. It also demonstrates a need for farmer education the timing of pesticides and other IPM measures that may be needed.

i. **Projected outputs:** (1) Molecular characterization data from Jamaican isolates of TEV; (2) Determination of TEV transmission efficiencies of the three most common aphid species found on pepper farms; (3) Identification of a cost effective weed management program for pepper farmers; (4) Establishment of risk indices for various components of a model for managing aphid-borne pepper viruses; (5) A strategy for the IPM management of broad mite will be developed, as part of an overall IPM for hot pepper. (6) Extension and farmers trained in IPM technology and training materials, (7) Journal publications and reports.

j. **Projected impacts:** Increased number of options will be made available to farmers cultivating hot peppers in Jamaica in spite of high virus pressure. This will ultimately lead to an improvement in the quality of hot peppers. For TEV, a farmer can use the risk analysis process to determine the best time and way to plant to minimize chance of early virus infection of peppers and increase profits at minimal management costs. In addition, characterization of TEV strains will validate the virus management program scientifically, and will provide specific virus isolates for breeders and molecular biologists for developing virus-resistant Scotch Bonnet peppers. An integrated management program developed simultaneously for TEV, PVY, and broad mite using stylet oil and other management components. Hot peppers are valuable export commodities. Broad mite can cause total losses of hot pepper crops, hence the economic impacts on farmers of broad mite attacks are large.

**k.** **Projected start:** Continuation; Broad mite work was started in year 8.

**l.** **Projected completion:** September 28, 2003 (Year 10)

**m.** **Projected person-months of scientist time per year:** 1.2; U.S. Scientist and Graduate students -2 months. Jamaican Scientist -4 months

**n.** **Budget:**
IPM CRSP: carry over funds - VA TECH; OSU $1,890; CARDI/MINAG $6,644

## I.5 An IPM Strategy to Combat the Gall Midge Complex Affecting Hot Pepper

The goal of this activity is to address fundamental issues surrounding the emergence of new pests, the gall midges (*Contarina lycopersci* and *Prodiplosis longifilia),* and their impact on the hot pepper export market.

**a.** **Scientists:** Jamaica: Dionne Clarke-Harris – CARDI, Carol Thomas – MINAG; Phillip Chung, Janette Lawrence – RADA; Denise Geoghagen- Food Storage and Prevention of Infestation Division; Agri-Business Council; USDA/APHIS. United States: Sue Tolin – Virginia Tech; Shelby Fleischer – Pennsylvania State Univ.; D. Michael Jackson – USDA.

**b.** **Status:** Continuing as a Technical Assistance/Mission project.

**c.** **Objectives:** The activities are outlined under six major components: (1) Determine the biology and taxonomy, behavior and ecology of the gall midge complex; (2) Develop an Integrated Pest Management strategy; (3) Improve post-harvest technology and its application in export fruits; (4) Transfer IPM technologies to farmers and extension officers; (5) Make the public aware of the importance of the gall midge complex; (6) Monitor and analyze the introduced IPM technologies.

**d.** **Hypotheses:** (1) An IPM strategy for management of the gall midge complex can be developed; (2) Hot peppers can be returned to the preclearance list for export products, through application of IPM, farmer and public education, and quarantine risk analyses.

**e.** **Description of research activities:**

**(1) Biology, behavior and ecology of the gall midge complex:** Information will be gathered on the life stages of the insects that result in damage to plant parts, and conditions conducive for survival and replication. Gaps exist in information regarding duration of life stages, and mode of reproduction, i.e. oviposition vs. larviposition. The infestation patterns of the pest in relation to crop phenology, variety, agroecology (temperature, rainfall, humidity), and cropping systems will be investigated. Farms representing various cropping systems within major pepper growing areas will be monitored for adults and larval infestations within fruits. The precise taxonomy of the midges will be confirmed, since the difference between the species quarantined by the U.S., *Contarina lycopersci*, and that found in the U.S., *Prodiplosis longifilia,* is very little. Contact will be made with quarantine officials to assess these data and the risks associated with introduction of the midges into the U. S.

**(2) Development of an IPM strategy:** This component will seek to identify and evaluate potential chemical, cultural and biological approaches, and evaluate which can be combined into a cohesive strategy for the long-term reduction of gall midge infestation levels. Trials will be established which compare cultural practices (stripping, pruning, removal of crop residues) in combination with various chemical insecticides (λ-cyhalothrin, malathion, diazinon, imidacloprid, fipronyl, neem formulation) to reduce midge populations and fruit damage. Persistence of chemical pesticides on various plant parts and soil will also be determined. A spray application guide will be developed for farmers, based on adult population levels and/or fruit infestation levels. Populations will be monitored with sticky traps and levels compared to fruit infestation levels in order to develop action thresholds and the most efficacious chemicals. Biological strategies for pest management will be initiated and will begin by surveys to identify natural endemic enemies, and to explore techniques to augment their incidence and suppression of gall midge populations. Commercial microbial entomopathogenic bacteria and fungi will be tested initially in the laboratory, and promising candidates will be field-tested. As information on IPM tactics is generated, data will be analyzed and the Best Management Practices identified and evaluated on farms in a continuous process.

**(3) Post Harvest Technology:** Research on the most effective and environmentally sound post harvest fumigation methods will be conducted, mainly comparison of methyl bromide, as required for all peppers shipped to the U. S., and less toxic fumigants such as magnesium phosphide (Magtoxin®) which is registered in the U.S. Data to be collected include larval mortality, persistence of the fumigant on fruit, and emission of the fumigant into the atmosphere, as well as effects on various pepper varieties, fruit maturity and various storage conditions. A procedural manual to highlight the proper post harvest management practices will be developed for farmers and exporters. Present methods for harvesting peppers result in destruction of fruit stalks and damage of fruit. The importance of proper sorting and grading for export at the field level and in the packhouses will be emphasized to maintain quality standards and to prevent insect-infested or damaged fruit from entering shipments.

**(4) Technology Transfer**: IPM technologies will be disseminated to farmers and extension officers in major hot pepper districts by methods revolving around farmer groups and individual farm visits. Priority will be placed on infested areas growing for the export trade. Topics include quarantine/market considerations; hot pepper production as a business; pest biology, ecology and damage; and pre- and post-harvest management. Demonstration plots will be established in seven major growing areas for use as training aids as well as to assist in field investigations. Farmer knowledge and practices will be assessed and integrated into the training methodologies.

**(5) Public Awareness:** The major public groups that interface with farmers growing for export are the exporters/agents that expedite shipments. Existing information will be used to prepare fliers, leaflets and posters to alert those in packinghouses, farm stores and other strategic rural community locations, and will be modified, as new information becomes available. A public media programme is being developed involving both electronic (radio, television) and a printed pamphlet. Jamaica Information Service is expected to provide *gratis* air-time, indicating the importance of this issue to the country.

**(6) Monitoring and Analysis of Introduced Technologies:** Pest interception levels will be monitored at the two major local ports, Montego Bay and Norman Manley (Kingston). A traceability system is being developed and implemented by the Jamaican Exporters Association to enable the origin (farmer, location) of each box of pepper being shipped to be identified. This system, coupled with monitoring of interception levels, will provide data to assist in determining area/farms where problems exist, as well as those from "clean" areas. Extension will provide data on problem areas so that appropriate interventions can be made to manage pests in those areas.

**f. Justification:** The gall midge affects not only affect the quality of the commodity but are of extreme quarantine importance to Jamaica's major trade partner, the United States. The USDA-APHIS issued a first warning to the Jamaican Ministry of Agriculture because this pest was detected, and negotiated a time frame of six months to appreciably reduce the level of interceptions of the midges. In response, Jamaica established a Multi-Agency Task Force, whose members are listed above, which has developed a national strategic plan for this issue. Because the situation was much more involved than originally envisaged, including conflicting information from the USDA as to identification and quarantine status, USDA then removed hot pepper from the pre-clearance list for shipment to the U.S. and requires mandatory fumigation of peppers before entry into the U.S. The IPM-CRSP will cooperate with this Task Force in this activity and provide technical assistance many of the object research activities.

**g. Relationship to other IPM-CRSP activities at the site:** One major component of the IPM-CRSP is development of IPM programs for hot pepper (Activity I.1). The gall midge activity will be integrated with other research objectives with hot pepper IPM, including technology transfer aspects. GIS and GPS technologies are being applied in Activity III.2.

**h. Progress to date:** This year activities focussed on monitoring and surveillance of the pest both at the field level and at the ports of exportation. Since the pest complex is of quarantine importance it is believed that strengthening the ability to know where and when the pest is present and intercepting it would be the best way to regain the confidence of USDA quarantine officials. There have been significant advances in the development and implementation of a traceability system for tracking pest-free and pest hot spot farms. A nine-digit code has been assigned to over 400 export farmers. This code links the farmer to a district and commodity, which allows for direct intervention by pest management personnel if pest interceptions on his crop become a concern. A web-based system for regional monitoring of the pest at the field level has also been developed and is currently being implemented. The web page is up and is being populated by data being collected islandwide. Major emphasis has also been placed on farmer training on the biology, and management of the gall midge.

Since the start of the project gall midge interceptions at Jamaica's two ports of exportation have decreased from over 100 cases in 1998 to under 10 cases in 2001. Based on recommendations coming out of the study and data on reduced gall midge interceptions the USDA was invited to revisit their position on mandatory fumigation. To this end a USDA delegation visited Jamaica in December 2001 to conduct investigations and the matter is still under review.

i. **Projected outputs:** (1) Improvements in the quality and quantity of exportable and locally consumed hot peppers. (2) Development of IPM options for managing gall midge populations. (3) Improvements in the knowledge base of farmers in pest management. (4) Increased number of farmers/extension trained in IPM. (5) Knowledge of the relation of the gall midge with respect to phenology of the crop and agroecology. (6) Identification of an action threshold for relation of gall midge populations to economic injury.

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

k. **Projected start:** September 29, 1999

l. **Projected completion:** September 28, 2003

m. **Projected person-months of scientist time per year:** 6 person-months

n. **Budget:** IPM CRSP through Technical Assistance: carried over funds – CARDI, with subcontracts to members of the Gall Midge Taskforce; US-AID Jamaica Mission: carried over funds – Virginia Tech.

## I.6 Molecular Probes to Distinguish Gall Midge Species

a. **Scientists:** S. Fleischer, L.Cui, B. Lovett – Penn State; D. Clarke-Harris – CARDI.

b. **Status:** New project funded through biotechnology special grants.

c. **Objectives:** We plan to develop a molecular probe that will rapidly distinguish *Contarinia lycopersici* and *Prodiplosis longifila* (or the un-named species) collected as either larval, pupal or adult life stages. We plan to then use this probe to help determine the geographic distribution of these two cecidomyiids in areas of the Caribbean and the U. S., and help improve our understanding of how management influences pest presence and population dynamics. We will also train 2 Caribbean scientists that current work in IPM in molecular biology techniques.

d. **Hypothesis:** Molecular probes can be developed that identify and distinguish between species of the gall midge complex.

e. **Research Activities:** We will collect both species from hot peppers in Jamaica. Collections will be from immature stages (larvae and pupae) in field trials that are currently underway at CARDI, and from grower's fields [e. g., through collaborations with work described in I.5.e(1) and I.5.e(2), above]. Collections will also be coordinated with survey efforts that are underway with RADA. Material will be reared to adults on pepper, aspirated, stored in alcohol, and transported to Penn State by CARDI.

A graduate student in Entomology at Penn State (B. Lovett) will develop a molecular probe to distinguish the taxa. Adults will be identified using methods and descriptions in Gagne (1986, 1989, 1994, 1998) and Pena et al., (1989). If we are dealing with a new species, the morphological work, which has already been initiated at CARDI, will be completed and published so this new species can be recognized. This requires dissection of male genitalia, and care will be taken to maintain parts together. We will send specimens to specialists for confirmation and as voucher specimens.

We will develop a simple molecular method to distinguish the two midge species. DNA will be extracted from ~50 of each taxa using standard protocol (Cui et al., 2000). We will first amplify a few house-keeping genes (e.g., genes encoding the ribosomal RNAs and actins) using the polymerase chain reaction (PCR) with degenerate primers based on conserved sequences of these genes from related insect taxa. The PCR products will be cloned and sequenced. Sequences will be compared to reveal regions where sequences have greatest variations or length polymorphism. Specific primers targeting unique sequences for each species will be designed. Since it appears that the two gall midge taxa are from different genera, it should not be difficult to identify house-keeping genes with sequence variations suitable for designing species-specific primers. These primers will be further tested by PCR using confirmed taxa identified by morphological characters. For future species identification, DNA from individual midges will be extracted by grinding and boiling in Tris-EDTA buffer. We have previously shown that DNA prepared in this manner is suitable for PCR. This PCR-based method for species identification has been developed and used for distinguishing many morphologically similar species including the closely related *Anopheles* mosquito species from Africa and different human malaria parasite species from the world (Scott et al., 1993; Snounou et al., 1993). Moreover, the PCR method is easy to perform and extremely sensitive to allow sufficient amplification from small amount of DNA extracted from the midges.

During year 1 of the project, we will bring 2 Caribbean scientists that currently work in IPM, and have been affiliated with the IPM CRSP work, to a 2 week intensive laboratory workshop on "Techniques in Molecular Biology", at Penn State University. This workshop is offered annually as summer update training to faculty and staff, and has received high reviews by past participants. The laboratory work is supplemented with lectures and discussion on the basic principles behind the techniques, their applications, related techniques, and current development in the techniques. The laboratory work covers purifying DNA, analyzing DNA by restriction enzymes, gel electrophoresis and nucleic acid hybridization, generating nucleic acid probes, cloning and screening for desired clones, DNA sequencing, PRC amplification, and protein analysis by western blotting. We will use the research effort proposed here, along with the training of Caribbean scientists and work related to plant virus research, to plan a lecture-based workshop on molecular tools for IPM in the Caribbean in later years.

This molecular probe will then be used on a series of collections from Jamaica and from collections taken from related taxa to help verify the specificity of the probe. In Jamaica, we will focus on areas where monitoring and management programs are being developed as part of current IPM CRSP objectives. This will help us determine the relative efficacy of these monitoring and management programs between the two species, and may help elucidate ecological differences between the species. We will also work closely with exporters, and use the probe to help determine the relative frequency of interceptions from each species over time and among geographic areas.

*Literature Cited:*

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**f.** **Justification/Background:** Hot pepper is an important crop to the Caribbean nations, which has a long tradition of excelling in pepper production. In Jamaica alone, it provides employment and income for 3,000 persons, injects US$5 million into the local economy, and attracts the attention of entrepreneurs. Peppers of various species are also very important in the US, where ~105,100 acres grossed ~$623 million annually, making *Capsicum* spp. the 3rd (fresh-market) to 4th (fresh plus processing) most valuable vegetable crop (NASS data). In the US, the hot sauce market alone is now valued at ~$550 million (Wall Street Journal 5/2000). Unfortunately, the ability of Caribbean farmers to capitalize on the growing export potential of their pepper crops is in jeopardy due to repeated interceptions of two species of gall midges at US ports. These were initially identified as *Contarinia* and *Prodiplosis longifila*, although recent taxonomic work suggests that at least one may be a new species. Only C. *lycopersici* is known to exist in the US, and APHIS imposed a quarantine to protect the US interests. This impedes economic growth in the Caribbean, and exports have declined dramatically. Also, the threat of the non-US species finding its way into the US regardless of the quarantine is a concern given the close proximity and travel between countries.

**g.** **Relationship to other CRSP activities at the site:** Other activities are described in I.5. A multi-agency and international task force initiated efforts to combat the gall midge complex in Sept. 1998. Caribbean participants include CARDI, the Jamaican government (MINAG and RADA), the private sector (Agri-Business Council, and Jamaican Exporters Association); US participants include APHIS. Progress has been made to identify and determine duration of life stages, and plant damage. Results were used to investigate cultural (fruit stripping) and chemical control tactics in field trials, and to develop field sampling methods (based on sticky traps for adults) and thresholds. Significant temporal and geographic variations in pest infestation were determined to exist throughout the island using GIS, and a regional monitoring program is now being established with web and GIS technologies. These IPM programs helped reduce densities, but not totally eliminate pest presence or threat of infestations being transported to the US. Therefore, additional studies are comparing fumigation methods, which are effective, but reduce shelf life and compromise fruit quality. To date, field and management studies are conducted on the pooled complex to the two species because there is no practical way to separate them, and no way to separate immature stages. The inability to distinguish species compromises the ecological and management value of the fieldwork, especially work most directly tied to interceptions because most interceptions occur as pupae.

h. **Progress to date:** New project.

i. **Projected output:** A molecular probe will be developed that distinguishes between the two species of gall midges that are infesting hot peppers in the Caribbean.

j. **Projected impacts:** This probe will enable plant protection workers who are not taxonomic specialists in the cecidomyidae to determine which species is causing the interceptions that are resulting in the quarantine. This tool will enable the monitoring and management efforts that are current CRSP objectives to be conducted at a species level (as opposed to a level where the data are grouped for the two taxa), and may reveal differences in how the species respond to the monitoring and management efforts, or ecological differences between the two species. Finally, this will also help the U.S. and Caribbean workers determine progress in their efforts to prevent infestation into the U.S. of a species that is not currently known to exist in the U.S., and train Caribbean IPM scientists in molecular biology techniques.

k. **Projected start:** September 29, 2002

l. **Projected completion:** September 30, 2004

m. **Projected person-months of scientists time per year:**

n. **Budget:** Penn State - $33, 662; CARDI - $9,350

### I.7. Use of Organic Mulches in IPM Programs for Sweetpotato and Hot Pepper in Jamaica

a. **Scientists:** D. Michael Jackson, Howard Harrison, Judy Thies, Janice Bohac, Dick Fery - USDA-ARS, US Vegetable Laboratory (USVL), Kathy Dalip – CARDI, Don McGlashan – MINAG, Bodles.

b. **Status:** New Activity as a USDA-ARS project (Funded outside IPM CRSP)

c. **Objectives:** Investigate the use of organic mulches (ie., killed cover crops) as an alternative tillage option for IPM programs with sweetpotato and hot pepper in Jamaica and the USA.

d. **Hypothesis:** Sweetpotatoes and hot peppers can be grown economically under alternate tillage systems that help ameliorate weed problems while reducing pesticide inputs, soil erosion, and pollution.

e. **Description of Research Activities:** Organic (killed legume cover crop) and inorganic (plastic) mulches will be tested in production systems of sweetpotato and hot pepper in

Jamaica. A tropical legume (possibly velvet bean or cowpea) will be used as a cover crop that will be killed with an herbicide before transplanting. If additional mulch is needed, it will be added to the field plots. For the Sweetpotato experiment, three Sweetpotato varieties (Sidges, a local variety; W-341, a nematode-resistant variety from the USDA breeding program; and PI-531116, a weevil resistant plant introduction from Nigeria) will be grown in three tillage treatments (conventional tillage [bare ground], plastic mulch, and organic mulch). Plots will be replicated three times in a split-plot randomized complete block design, with the tillage treatments being the main plots and the Sweetpotato entries being the subplot treatments. Each subplot will be consist of 3 rows, 20 feet long. Data will be collected from the center row of each subplot. For each variety, ca 1275 cuttings will be needed. Parameters measured will include sweetpotato yield, sweetpotato quality (grades), soil insect damage ratings, root knot nematode ratings, and weed evaluations, using established evaluation techniques. Normal fertilization and irrigation practices will be followed, and one cultivation (hand hoeing) will be done at 2-3 weeks after transplanting. Pitfall traps will be established to monitor levels of beneficial predators. The pepper experiment will be similar in design, with the 3 varieties being a local scotch bonnet cultivar, West Indies Red, and PA-426, a root knot nematode-resistant, yellow germplasm release from the USDA, USVL. Experiments will be conducted at the Bodles Experiment Station (MINAG), St Catherine, Jamaica. These experiments will be repeated at the USVL, Charleston, SC to help refine techniques for use in the Caribbean; however, the variety selection in the US experiments will be altered to reflect American agricultural interests.

**f.** **Justification:** Weed management remains a major obstacle to crop production worldwide. Organic mulches are used extensively in temperate regions, but are not as widely used in subtropical or tropical regions, mostly due to greater pest pressures found in warmer climates. Organic mulches offer several advantages over conventional bare-ground or fumigated plastic-mulch production. They suppress weeds, reduce soil erosion, prevent pollution of surface and ground water by slowing runoff and leeching of nutrients and chemicals, provide habitats for beneficial insects and beneficial microorganisms, reduce the impact of certain disease organisms, and enhance production in systems where nitrogen-fixing legumes are used as killed-cover crop mulch. However, there are also some disadvantages to this technology that must be overcome before is can be successfully implemented. Disadvantages associated with organic mulches include difficulties in cultivation, harboring of disease or pest insects, and problems in establishing the crop. To adapt organic mulching systems to tropical environments, a better understanding of the system dynamics for a particular location is needed. Thus, this technology must be rigorously tested at each location. The use of pest-resistant cultivars in these experiments is justified because it will help ameliorate the potential disadvantage of increased pest and disease organisms in organic mulch systems.

**g.** **Relationship to other IPM-CRSP activities at this site:** This work complements efforts on sweetpotato outlined in I.2 above. The EEP report highlighted a need for increased efforts on weed management. This project addresses this concern.

**h.** **Progress to date:** New project. Similar work had been done prior to year 6.

**i.** **Projected outputs:** Develop alternate tillage systems for sweetpotato and hot pepper that help reduce dependence on chemical herbicides for weed control; that address other pest concerns, and that increase yield and quality in sweetpotato and hot pepper cropping systems in Jamaica.

j. **Projected impact:** Organic mulch tillage systems for sweetpotato and hot pepper will provide a sustainable alternative to production conventional systems, while reducing pesticide impact.

k. **Project start:** October 1, 2002.

l. **Projected completion:** September 30, 2003.

m. **Projected person-months of scientist time per year:** 2 Months

n. **Budget**: $20,000 (Over year 9 and 10) – USDA, ARS, US Vegetable Laboratory; $5,000 would be transferred to Jamaica through a contractual agreement.

## II. Pesticide Use and Residues

### II.2 Persistence and Non-target Effects of Pesticides on Hot Pepper and Leafy Vegetables in the Tropics

a. **Scientists:** Clive A. Edwards (OSU), , Dwight Robinson (Univ. West Indies), Kathy Dalip (CARDI), Dionne Clarke-Harris (CARDI)

b. **Status:** Continuing activity with the addition of some new activities. Not all year 9 objectives were attained due to lack of funding for expensive residue analyses in year 9.

c. **Objectives:** The original intent of this topic was to assess the extent to which pesticides used on callaloo, peppers and cabbages leave residues on the crop. We hypothesize that many of these pesticides can be detected in produce in local and export market marketplaces. Thus, the activities described below will attempt to quantify pesticide residues that can either cause environmental or human health problems or result in produce rejection in the marketplace. Adverse effects on soil organisms (and hence soil processes) may also be the result of excessive pesticide use or the use of those chemicals that degrade very slowly under field conditions. In Year 10 work will focus on human and environmental elements of pesticide risk analyses, from the more popular pesticides used on hot peppers and cabbages in order to make more specific recommendations for their safe use in the Caribbean. This work will be collaborative with the Pesticide and Pest Research Group (PPRG) on the Mona Campus of the University of the West Indies (UWI) in Jamaica, the major agency for the development of capabilities in pesticide residue analyses and toxicological research for the region. The work proposed will assist pioneer efforts toward ISO HAACP systems development within the region.

**Specific objectives**:
(a) To ensure that hot peppers, callaloo and cabbages for export, or local sale, are not contaminated with pesticides; (b) To ensure that pesticides used on hot peppers, callaloo and cabbages do not have adverse effects on soil invertebrates and soil processes; (c) To continue to develop local capabilities for pesticide residue analysis and co-ordinate in-country capabilities.

**d.** **Hypotheses:** (a) Hot peppers, callaloo or cabbages for export may have pesticide residues at levels that would restrict their import into the U.S.; (b) 'Half life' values for pesticides under tropical humid Caribbean conditions will be less than those in temperate climates; (c) Some pesticides are much more persistent on plant foliage and in soil than others.

**e.** **Description of research activities**

*Pesticide persistence on hot peppers.* The persistence of the most commonly used pesticides: fipronyl, imidacloprid, 8-cyhalothrin, diafenthuron profenofos, diazinon and malathion on hot peppers in the field, will be determined in both rainy and dry seasons. Treatment plots with 16 plants will be laid down and the pesticides applied at fruitset, taking care to confine treatments to treated plots. Leaf samples will be taken at 0, 3, 7, 14 and 21 days after pesticide application and fruit samples will be taken at harvest and extracted and analyzed by GLC to determine $T_{50}$ values

*Pesticide persistence on cabbages.* Similar experiments to those on hot peppers will assess the persistence of pesticides used commonly on cabbages on foliage and in the soil using a similar experimental design. Pesticides tested will be λ-cyhalothrin, profenfos, diafenthurion, diazinon and methonyl.

*Pesticide persistence in soil.* These experiments will continue in year 10 The soil in small plots 2 m x 2 m will be treated directly with the same insecticides used in the previous section on callaloo, hot peppers and cabbages and pesticide residues analyzed 2 weeks, 4 weeks and 8 weeks after the pesticide applications. The residues will be extracted from soil samples and analyzed by GLC.

*Effects of pesticides on non-target soil organisms.* The investigation will use the same plots in which the persistence of pesticides in soil is assessed. Four 5 cm diameter x 15 cm deep soil cores will be taken from each plot 2 weeks, 4 weeks and 8 weeks after pesticide applications, the soil-inhabiting insects, mites and other invertebrates extracted in Tullgren funnels, then identified to orders, families and ecological trophic groups.

*Provision of training and upgrade of pesticide residue analytical capabilities in Jamaica.* The University of West Indies residue laboratory currently is close to having the capability to analyse for diazinon, malathion, chlorpyrifos, ethoprophos, profenos, deltamethrin, λ-cyhalothrin and permethrin, but needs their analytical equipment (HPLC) upgraded. In year 10, the pesticide residue analyses will be done jointly by OSU and the University of West Indies. We are providing standards and plans to upgrade their capabilities to cover all commonly-used, relevant synthetic halogenated pesticides those containing a phosphorus group or those based on pyrethroids. Sources of funding to upgrade the analytical capabilities will be sought from international aid and grant-providing agencies. There is a current potential to obtain funding for this purpose from the European Union.

**f.** **Justification/Background:** Increasing stringency in acceptable residues on import crops to USA and Europe make local and regional pesticide residue analytical capabilities essential. There is a dearth of information on the persistence of pesticides in soil and on plants under humid tropical conditions although they are known to differ from those in temperate climates. Knowledge of pesticide residues on food crops is also quite important to the health of local people.

g. **Relationship to other CRSP activities at the site**: The aim of CRSP activities is to implement IPM that minimizes pesticide use. These pesticide residue studies assess the success of the IPM programs.

h. **Progress to date**: The facilities for pesticide residue analytical capabilities have been improving gradually in Jamaica and there is now a competent residue chemist. We have accumulated considerable data on residues from market basket surveys and sampling of export crops. The current continuing study will eliminate the need for residue analyses of a number of pesticides which are relatively transient in soil and on foliage or fruit, and which therefore present little hazard to the consumer. To date in year 10 we have completed the residue studies on callaloo and are organising the hot pepper trails. Funding constraints may limit the residue analyses we can complete in year 9 but we shall take the studies as far as possible and focus on studies on residue on cabbage and effects on soil organisms in year 10.

i. **Projected outputs:** Elimination of the need for analyzing residues of a range of pesticides. Identification of spraying harvest intervals for pesticides that are commonly used on hot peppers and cabbages.

j. **Projected impacts:** Facilitation of pre-clearance exports of hot peppers. Minimization of contamination of all hot pepper and cabbage crops is an important environmental issue.

k. **Projected start:** Continuation project

l. **Projected completion:** September 30, 2003

m. **Projected person months of scientist time per year:** 2 months

n. **Budget:** $ 9,020 – CARDI; $ 10,000 – OSU

## III. Social, Economic, Policy and Production System Analyses

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

### III.1 An Assessment of Production, Post Harvest and Marketing Practices that Impact upon Export Market Opportunities for Hot Pepper and Callaloo

a. **Scientists:** Vassel Stewart, Dionne Clarke-Harris – CARDI; Janet Momsen – U. Calif. Davis.

b. **Status:** Continuing Activity

**c.** **Objectives:** (1) Describe the production systems and marketing systems of hot pepper; (2) Analyse throughput systems from farm gate to major consumers; (3) Analyse the demand and market potential for target crops for the next 3 – 5 years with special reference to markets in the USA (Miami/New York) and the Caribbean region (Trinidad and St Lucia); (4) Determine marketing constraints that can be addressed by the use of IPM technologies; (5) Describe the production and marketing systems of callaloo.

**d.** **Hypotheses:** (1) Knowledge and analysis of marketing requirements assist in the development of IPM technologies; (2) Development and implementation of proper marketing systems will greatly influence the adoption of IPM technologies; (3) Adoption of IPM technologies will assist in reducing pest interceptions on export products shipped form Caribbean countries; (4) Linking crop production to marketing systems will increase overall impact and sustainability of callaloo as an export commodity.

**e.** **Description of research activities:** A business systems approach, which recognizes the market, as a major influential force driving the development and use of technologies will be applied. A four-step process is involved – *problem definition/needs analysis, research, a pilot study and implementation.* During Year 9, we will focus on Steps 1 and 2 with the hope that Steps 3 and 4 can be the targets for the remainder of the project. It should be noted that, this exercise was initiated during Year 4; data gathered during this initial exercise is now being used as a framework to identify areas for further in-depth data gathering and analysis.

Secondary data on *production, export, rejection of commodities at ports, market demands, market prices, trade policies (local, regional and international*) will be gathered. Structured interviews with all persons involved in the production and marketing chain (*– farmers, higglers, middlemen, exporters, brokers, and consumers*) will also be conducted to obtain complete information on the production systems and marketing of the target crops in Jamaica and the United States. All data will be analyzed, such that areas within the present system that will constrain the adoption of IPM technologies being developed will be identified. Also, possible modifications will be identified that would improve the systems being proposed. In addition, the data will be analyzed to determine if the technologies that are being developed satisfy present and future market requirements. Projections on market potential for the next 3 – 5 years will be made.

**f.** **Justification:** IPM Technologies need to be developed within the context of consumer demands/market requirements. Farmers utilising these technologies and satisfying these requirements should therefore have an advantage within the market place. The success of any IPM system is market driven. Therefore, production and marketing systems must be developed to facilitate and promote the utilisation of IPM technologies. Studies conducted in Year 4 indicated deficiencies within the present system; however, before recommendations for changes can be made, further data gathering and analysis is needed.

**g.** **Relationship to other IPM-CRSP activities at the site:** Results from the studies complement the activities being conducted in the IPM systems development component, and will supply valuable information to help refine present IPM technologies.

**h.** **Progress to date:** A baseline study, completed in Year 4, provided data on production, supply, price structures and indices for each of the target crops. Area specific linkages in production and marketing were determined as well as market opportunities locally and internationally identified. A follow-up study conducted during Year 8 at U.S.A ports in Miami and New York have helped define the structure of the market supply and demand side, and its vagaries. The study also helped to estimate the market volume, the peak period of the market demand and the growth path of the market. These findings will be used in Year 9 to guide the implementation of systems and relevant research approaches. IPM CRSP findings have been disseminated to various national and regional stakeholders involved in the hot pepper commodity system, through meetings and reports. These findings have also played a part in the development of the Terms of Reference and priorities of national and regional hot pepper industry associations being promoted by CARDI.

i. **Projected outputs:** (1) Documentation of present marketing systems; (2) Quantification of losses; (3) Identification of the deficiencies of present systems and possible improvements; (4) Identification of market opportunities for the target crops.

j. **Projected impacts:** The study will assist in development of appropriate technologies and marketing systems that will improve competitiveness advantage of the target crops in local and international markets.

k. **Projected start:** September 29, 1995

l. **Projected completion:** September 28, 2003

m. **Projected person-months of scientist time per year:** 4

n. **Budget**: IPM CRSP: $ 3,000 - CARDI.

### III.2 Social and Gender Analyses

a. **Scientists:** Dionne Clarke-Harris – CARDI; Janet Momsen – U. Calif. Davis; Colette Harris –Virginia Tech

b. **Status:** Continuing Activity – Renewed

c. **Objectives:** Complete analysis of base-line survey information on gender and social issues.

d. **Hypothesis:** Knowledge of gender and social constraints will assist in the development of IPM technologies.

e. **Description of research activity:** This exercise was initiated in the early years of the project. Data gathered during this initial exercise were analysed in part, but have not identified areas for application to IPM implementation. All data will be analyzed, such that areas within the present system that may constrain the adoption of IPM technologies being developed will be identified. Also, possible modifications will be identified that would improve the systems being proposed. In addition, the data will be analyzed to determine if the technologies that are being developed satisfy present farmer requirements.

f. **Justification:** IPM technologies need to be developed within the context of the social system of the farming communities and families. Farmers satisfying the requirements for IPM adoption and utilizing these technologies and should therefore have an advantage within the market place. The success of any IPM system is market driven. Therefore, social systems must be compatible with the utilisation of IPM technologies. Studies conducted in earlier years have not been analysed completely. Before recommendations for changes can be made, further analysis is needed.

**g.** **Relationship to other IPM-CRSP activities at the site:** Results from the studies complement the activities being conducted in the IPM systems development component, and will supply valuable information to help refine present IPM technologies.

**h.** **Progress to date:** All data have now been tabulated and described.. From this initial summary specific analyses will be performed.

**i.** **Projected outputs:** (1) Documentation of various social and gender issues in present farming systems; (2) Information to assist in training programs.

**j.** **Projected impacts:** The study will assist in development of appropriate technologies and training programs that will improve the adoption of IPM practices in the Caribbean.

**k.** **Projected start:** September 29, 1997; restarted in 2002.

**l.** **Projected completion:** September 28, 2003

**m.** **Projected person-months of scientist time per year:** 2 months

**n.** **Budget:** U. C. Davis: $4,000.

## IV. IPM Enhancement

The goal of this topic is to address the fundamental problems that are encountered when conducting interdisciplinary, multinational, collaborative IPM research. These include: (1) Constrained communications due to distance, language, and culture; (2) The ability of scientists from the U.S. and developing countries to understand the technical and practical aspects of research problems and components of those problems; (3) Sensitivity of scientists to the diversity of opinions and perspectives that characterize these types of research teams. (4) The lack of expertise in certain discipline areas, such as weed science and management, and information technologies.

### IV.1 Research Enhancement through Training

**a.** **Scientists:** Dionne Clarke-Harris– CARDI; S. Fleisher – Penn State; C. Edwards – OSU.

**b.** **Status:** New Activity

**c.** **Objectives:** To identify candidates for advanced training in weed science or management, in information technology, and/or in rapid diagnostic methods using biotechnology, related to integrated pest management.

**d.** **Hypotheses:** Education of in-country persons in these areas, through short-term training experiences, will enhance the capability of IPM research in the Caribbean.

**e.** **Description of research activity:** The research area of the graduate student will be directly related to one of the activities described in Section 1, and will augment the research in one or more of these areas to develop new technologies.

f. **Justification:** IPM technologies need to be developed which address the tremendous weed, disease and insect pest pressure in the tropical areas of the Caribbean. Formal training in weed science and integrated weed management approaches, in molecular diagnostics, and use of information technologies in IPM, is lacking.

g. **Relationship to other IPM-CRSP activities at the site:** Most IPM systems have both a weed, pathogen or pest component, as well as an information component. During the candidates' studies, they will gain valuable information to help refine present IPM technologies.

h. **Progress to Date:** A scholarship in weed science was advertised throughout CARDI member countries. However the offer has not yet provided a suitable candidate. The approach to be made in Year 10 is to identify individuals for short-term, rather than advance degree training. Plans are made to train individuals in information technology, insect and pathogen diagnostics with PCR methodologies, and to continue to seek a candidate for weed management.

i. **Projected outputs:** (1) Completion of specialized training in areas related to IPM; (2) Knowledge gained to assist in capacity building.

j. **Projected impacts:** The trainees will assist in development of appropriate technologies and programs to improve the adoption of IPM practices in the Caribbean.

k. **Projected start:** September 1, 2002

l. **Projected completion:** September 28, 2004

m. **Projected person-months of scientist time per year:** 6 months

n. **Budget:** IPM-CRSP: Carryover funding. Biotechnology funding (Activity I.6).

### IV.2. Integration of World-wide Web and GIS - for Real-time Monitoring, Communication, and Dissemination of Pest Management Information

a. **Scientists:** Dionne Clarke-Harris – CARDI; Sue Tolin – Virginia Tech; Shelby Fleischer, Bruce Miller – Pennsylvania State Univ.

b. **Status**: Continuing Activity

c. **Objective:** Develop and implement real-time pest monitoring, mapping, and web display of both maps and time-series over geographic areas, using the gall midge as the model system, with applicability to other pest monitoring programs. Identify pest-free or low pest incidence areas to reduce quarantine restrictions for export. Identify high pest incidence areas for more rapid responses by Extension agents and researchers. Develop on-line information and management guides relating to IPM technologies being evaluated, as a means of information dissemination and exchange.

d. **Hypotheses:** (1) The internet and email are increasingly the preferred means by which IPM technologies can be disseminated throughout the Caribbean; (2) Increasing the availability of pest management information will accelerate the transfer of technology being generated; (3) Mapped displays of pest monitoring data over wider geographic areas linked to time series information at local sites will help identify pest-free areas and areas in need of more intensive management and education; (4) Web-access to mapped displays linked to local time series will facilitate linkages and communication among public and private sectors involved with pest management and crop marketing.

e. **Description of research activities:** Through previous and future training programs, in-country capabilities will be developed for GIS. The data will be entered in a format (newly developed at Penn State) that is accessible via the CIPMNET website. Data will be collected from four targeted areas on a weekly basis. Sampling will involve collection and dissection of fruit and buds, using three locations for the dissections. Spatially referenced password-protected data input will occur via forms on the web, routed through the RADA server, and will automatically update a spatially referenced database on the RADA server. A Penn State application will download this database, and be implemented routinely to create new maps of pest infestation rates, and clickable views of the time series at local sites. All maps and time series will be ported to a website. We envision this type of information infrastructure, which we develop here as part of the gall midge program in the IPM CRSP, to be useful for other pest monitoring and management programs in the future. We also envision this to facilitate cooperative linkages among research and Extension agencies.

f. **Justification:** In the Caribbean, the PROCICARIBE network has been established to provide for exchange of information in pest problem identification and management strategies. It is a natural extension of the IPM-CRSP project to assist in the development and operation of information systems technologies for IPM.

g. **Relationship to other IPM-CRSP activities at the site:** Outputs generated as a result of these activities will greatly accelerate the regionalisation of the IPM CRSP in the Caribbean, and greatly accelerate pest monitoring of other pests in multiple Caribbean sites. The development of integrated web/GIS for pest monitoring using distributed data-entry, update and geographic display also has utility in many IPM CRSP sites. The first development in the Caribbean site will serve as a study of prototype development for other sites, enabling development of appropriate and relevant software, and a clear understanding of necessary resources and infrastructure.

h. **Progress to Date:** We will build from a multi-agency workshop, a RADA baseline survey, and a GIS thesis, all of which were completed in Year 8. The multiagency workshop (RADA, MINAG, CARDI, Penn State, UWI, Agro Grace, H&L Agri & Marine Co., Agricultural Chemicals Plant, Pesticide Control Authority) reviewed application software for the integration of web and GIS for pest monitoring, and identified target areas for implementation. These target areas were prioritized by pest infestation rates, level of hot pepper exports, and variation in factors that statistically influenced models of infestation rates (elevation, farmer crop and pesticide practices). The four targeted areas were St. Mary, Westmoreland, southern St. Catherine, and southern Clarendon.

i. **Projected outputs:** (1) A Web-based GIS system for recording pest distribution and implementing management practices; (2) Electronic Pest Management Guides for use in training workshops.

j. **Projected impacts:** Preparation of electronic pest management guides will assist in improving the knowledge base of extension and researchers inter and extra regionally.

WEB/GIS will provide spatial and textual information on pest distribution and impact management strategies. Management inputs will be more targeted to specific geographic areas. Pest-free areas will be defined and may be useful for reduced quarantine restrictions.

**k.** **Projected start:** September 29, 2000

**l.** **Projected completion:** September 28, 2003

**m.** **Projected person-months of scientist time per year:** 2 months

**n.** **Budget:** IPM-CRSP: $ 7,700 - CARDI; $9,618– Penn State; Other: CARDI; Virginia Tech – Scientists time.

**INTEGRATED PEST MANAGEMENT-COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP)**
**CARIBBEAN SITE SUMMARY TABLE**

(September 30, 2002 – September 29, 2003)

| ACTIVITY | SCIENTISTS | YEAR 10 BUDGET ($) | OTHER BUDGET ($) |
|---|---|---|---|
| **I. IPM SYSTEMS DEVELOPMENT** | | | |
| I.1. Threshold-based Integrated Management of Pests Affecting Leafy Vegetables with High Pesticide Input | Jamaica: D. Clarke-Harris, F. D McDonald – CARDI; P. Chung – RADA;<br>Barbados Michael James Ministry of Agriculture and Rural Development<br>Trinidad Lilorie McComie, Ministry of Agriculture<br>United States: S. Fleischer – Penn State Univ. | 30,580<br>5,005<br>5,005<br>7,814 | |
| I.2. IPM of Major Pests Affecting Sweetpotato in the Caribbean | Jamaica: K. Dalip – CARDI; D. McGlashan – MINAG;<br>St Kitts: L. Rhodes – CARDI; and Montserrat - L. Rhodes CARDI<br>St Vncent and the Grenadines- R Andall CARDI<br>United States: J. Bohac, D. M. Jackson – USDA; C. Edwards, Ohio State | 25,630<br>3,905<br>4,598<br>11,100 | |
| I.3. Assessment of Virus Incidence in Superior Caribbean Sweetpotato Varieties | Jamaica: K. Dalip – CARDI;<br>United States: D. M. Jackson – USDA; S. Tolin, Virginia Tech | 5,108 | |
| I.4 Integrated Pest Management (IPM) Strategies for Reducing Impact of Tobacco Etch Virus and Broad Mite on Hot Peppers | Jamaica: D. Clarke-Harris, K. Dalip, R. Martin – CARDI; J. Goldsmith, D. McGlashan, M. Williams – MINAG; P. Chung – RADA; W. McLaughlin – UWI;<br>United States:<br>C. Edwards, M. Schroeder – Ohio State;<br>S. Tolin – Virginia Tech | 11,000<br>4,662<br>3,111 | |

| | | | |
|---|---|---|---|
| I.5. An IPM Strategy to Combat the Gall Midge Complex Affecting Hot Pepper | Jamaica: D. Clarke-Harris – CARDI; F. Young, C. Thomas – MINAG; P. Chung, J. Lawrence – RADA;<br>United States: S. Tolin – Virginia Tech; S. Fleischer – Pennsylvania State Univ.; D. M. Jackson – USDA. | | 34,650<br>7,092<br>3,258 |
| I.6. Molecular Probes to Distinguish Gall Midge Species | Jamaica: Dionne Clarke-Harris - CARDI;<br>United States: S. Fleischer, Luiwang Cui – Pennsylvania State University | | 9,350<br>33,257 |
| I.7. Use of Organic Mulches in IPM Programs for Sweetpotato and Hot Pepper in Jamaica | Jamaica: Kathy Dalip – CARDI, Don McGlashan – MINAG, Bodles;<br>United States: D. Michael Jackson, H. Harrison, J. Thies, J. Bohac, D. Fery - USDA-ARS, US Vegetable Laboratory (USVL), | | 5,000<br>17,200 |
| **II. PESTICIDE USE AND RESIDUES** | | | |
| II.1. Persistence and Non-target Effects of Pesticides on Hot Pepper and Leafy Vegetables in the Tropics | Jamaica: K. Dalip, – CARDI; D. Robinson – UWI;<br>United States: C. Edwards – Ohio State | 2,970<br>6,426 | |
| **III. SOCIAL, ECONOMIC, POLICY, AND PRODUCTION SYSTEM ANALYSES** | | | |
| III.1. An Assessment of Production, Post Harvest and Marketing Practices that Impact upon Export Market Opportunities for Hot Pepper and Callaloo | Jamaica: D. Clarke-Harris – CARDI;<br>Trinidad: V. Stewart – CARDI;<br>United States: J. Momson - UCDavis | 2,970<br>1,250 | |
| III.2. Social and Gender Issues Affecting IPM Adoption | Jamaica: D. Clarke-Harris – CARDI;<br>United States: J. Momson – U.C. Davis | 4,000 | |

| | | | |
|---|---|---|---|
| **IV. IPM ENHANCEMENT THROUGH INFORMATION TECHNOLOGIES** | | | |
| IV.1. Research Enhancement through Training | Jamaica: student to be selected<br>United States: PSU or VT | | 11,525 (carry over) |
| IV.2. Integration of World-Wide Web and GIS for Real-Time Monitoring, Communication, and Dissemination of Pest Management Information | Jamaica:, D. Clarke-Harris CARDI; P. Chung, RADA;<br>United States: S. Fleischer, B. Miller, Penn State Univ., L. Grossman, S. Tolin, VA Tech; | 5,500<br><br>8,415 | |

# Tenth Year Work Plan for the West Africa Site in Mali

In IPM CRSP Year 10, the last year of Phase II, the Mali site will conclude its first phase with a primary focus on periurban export horticulture and conclude its secondary focus on innovative research for control of *Striga, a* parasitic weed on basic food crops. Three crops have been the focus of the horticultural research: green beans, hibiscus, and tomatoes. This research has been developing in stages over the five-years of Phase II: the first stage emphasized primary on-farm research; the second stage focused on the testing of pest management techniques as integrated packages; and, the third stage will involve disseminating farmer-tested IPM packages. We are now in the third stage of disseminating integrated packages for green bean and hibiscus, with research advancing on tomatoes with particular emphasis on white flies and the tomato yellow leaf curl disease. Innovative research on seed dressing with herbicides for control of *Striga* on basic food crop cereals millet and sorghum, begun in 1999, will be concluded. Research on the best modes of technology transfer have been introduced into Farmer Field Schools in the targeted villages and is being expanded to additional villages.

In addition, these research efforts serve to support the development of a system to reduce pesticide residues on agricultural products in collaboration with the new Environmental Quality Laboratory (EQL) of the *Central Veterinary Laboratory (LCV)*. Rational use of pest control measures may include synthetic pesticides. Pesticide residue analysis provides information on both the current performance and potential improvements of the system. Combined with on-farm research, pesticide residue analysis can aid 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.

This program is being carried out with three Malian institutions playing a leading role: the agricultural research institution *Institut d'Economie Rurale (IER*), the extension organization *Opération Haute Vallée du Niger (OHVN),* and the toxicology laboratory of the *Central Veterinary Laboratory (LCV)*. *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. The *Institut Supérieur de Formation et de Recherche Appliquée* of the *University of Mali* is collaborating in training of a Ph.D. student and two masters'students.

In the United States, five institutions will contribute to the collaborative research program: *Purdue University*, contributing expertise in vegetable IPM; the *University of California-Davis*, contributing expertise in tomato virology; *North Carolina Agricultural and Technical University*, contributing expertise in economics of horticultural production and export markets; *Montana State University*, contributing expertise in natural pest control products and technology transfer; and *Virginia Tech*, contributing expertise in weed science, rural sociology, pesticide residue analysis, pesticide safety education, and quality assurance. One entomology Ph.D. graduate student at University of Mali will participate in a sandwich program during Fall 2002 at *Purdue University*, a biochemistry student from the *LCV* will be pursuing a master's degree at *Virginia Tech*, and an agricultural economics student will continue their Masters program at *North Carolina A & T.*

**I. Periurban Export-Oriented Green Bean Pest Management Research**

**I.3. Integrated Weed Control Strategies for Green Bean Production**

**a.** **Scientists**: Subactivity leaders: Moussa N'Diaye, IER; Jim Westwood, Virginia Tech; Collaborating scientists: Bouréma Dembélé, IER; Kadiatou Touré Gamby; IER; Haoua Traoré Sissoko, IER

**b.** **Status**: Continuing

**c.** **Overall Objective(s):** To develop integrated weed control strategies for periurban green bean production systems.

**Objective(s) for coming year**: (1) To continue experiments examining strategies for control of difficult weeds such as *Cyperus rotundus*: (a) hand weeding (b) herbicides (c) mulches, (d) burning residues, and (e) potash; (2) To determine the critical weed-free period for green beans; (3) To begin integrating weed control methods into a comprehensive green bean production program.

**d.** **Hypotheses**: Supplementing hand weeding with weed control techniques such as herbicides and mulches can control *Cyperus rotundus* and reduce time needed for weed control operations. Potash has a phytotoxic effect that may form a component of an integrated weed control program.

**e.** **Description of Research Activity**: Hand weeding is an effective weed control strategy in the small plots typically used for vegetable production in the Bamako area. However, certain persistent weeds such as *Cyperus rotundus* present a continuing problem, and control could be improved with judicious use of herbicides or other control techniques such as mulches. Preliminary experiments showing that potash may be used as a locally produced and inexpensive herbicide will be continued in order to answer important questions. This new approach will be compared to techniques such as burning straw on the plots, direct application of ash, mulching with animal manure, application of the herbicide glyphosate, and current farmer practices. Potash treatments will be characterized by dose response studies to define the concentrations and intervals needed to control *Cyperus* species. The time required for the toxic effects of the potash to dissipate will also be determined, and methods to reduce this time will be tested. Mulching will also be studied to identify optimal quantities needed to suppress *Cyperus* growth. An experiment to determine the critical weed-free period for green beans under Malian conditions will be conducted to optimize all weed control efforts.

**f.** **Justification**: Weeds can cause significant yield reductions in green beans, both through direct competition for resources, and through the harboring of pathogens or pathogen vectors. *Cyperus rotundus* is one of the primary weeds of irrigated vegetables in the area around Bamako and is difficult to control.

g. **Relationship to Other CRSP Activities in Mali**: This work will be coordinated with other periurban pest protection practices being developed under this project, with the goal of developing a complete weed/insect/pathogen control program. These activities will also be conducted in parallel with weed control practices in hibiscus and tomatoes.

**h**. **Progress to Date**: A detailed inventory of weeds common to green bean culture has been compiled. Potash has been identified as a cheap and readily available means to control plants, although problems persist concerning its toxicity to desirable species.

**i**. **Projected Outputs**: High yield of green beans, with reduced labor expenditure through the efficient control of weed species in vegetable production systems. As the efficacy of the weed control strategies are determined, techniques will be incorporated into the curriculum of the Farmer Field Schools and described in the final report.

**j**. **Projected Impacts**: Improved weed control practices will maintain high yields, and hence grower revenue, while reducing the time and energy needed for weed control. Growers will have the potential for increasing production through increasing area of cultivation.

**k**. **Start**: October 1999

**l**. **Projected Completion**: September 2003

**m**. **Projected Person-Months of Scientists Time per Year**: 2-3 person months.

**n**. **Budget**: IER/Sotuba – $2,420; University of Mali – $9,000; OHVN – $720; Virginia Tech – $192

## II.3. Development of an Integrated Package for Management of Insects and Weeds affecting Hibiscus

**a.** **Scientists**: _Subactivity leaders_: Mme. Gamby Kadiatou Touré, Moussa Noussourou, Bourema Dembele, IER; Rick Foster, Purdue, Jim Westwood, Virginia Tech; Collaborating _scientists_: Mme. Sissoko H.Traoré - IER; Anthony Yeboah - North Carolina A & T.

**b.** **Status**: Continuing Activity

**c.** **Objectives**: To develop an integrated system for managing insect and weeds pests of hibiscus.

**d.** **Hypotheses**: Use of an integrated IPM package for management of insects and weeds on hibiscus will result in higher yields.

**e.** **Description of research activities**: Two treatments will be compared on three farms at Sanambélé, Koren, and Dialakoroba with one farmer in each village. (1)Farmer Practice: This will be left up to the farmer, but routine practice is to plant hibiscus after millet and sorghum have been planted. Few attempt to control either insects or weeds. Some use cotton pesticides for insect control. Neither organic nor mineral fertilization is used. (2) IPM Technologies: Planting date will be the start of the rainy season. Two hand weedings will be made. Two tons of organic matter will be applied per hectare. Four applications of neem extracts for *Nisotra* and other insects will be made. Data collection will include: (1) weekly insect counts (N*isotra* on leaves); (2) weed infestation levels per square meter; (3) yield of fresh flowers and dry flowers; and (4) quality of dry flowers. In addition, a station trial of varieties will be conducted. The varieties to be tested are Thailand 1, Thailand 2, Vinto and Senegalese. The trial will involve a simple CRD experiment with 4 repetitions. Variables to be measured are insect numbers weekly, % defoliation weekly, and yield.

**f.** **Justification**: The American company Celestial Seasonings is importing Malian hibiscus. Malian hibiscus also has established itself in the markets of neighboring countries. Since the flower of the plant is used to make drinks, pesticide applications after flowering carry the highest risk of causing residue problems. The coleopteran insects *Nisotra uniformis* and *N. pallida* and hemipteran insects *Dysdercus* spp. are the main insect pests of hibiscus. Farmers apply Decis on hibiscus approximately every 10 days, for a total of 4-5 applications per season. OHVN is interested in using the commercial neem product 'Neem-Away' but lacks scientific data to assess its effectiveness. Locally produced neem could be an alternative to the commercial neem product.

Preliminary results indicate that the use of vaseline covered traps and neem can provide levels of control comparable to broad-spectrum insecticides. In addition, research has shown that the hemipteran predators of *Nisotra* spp. may be an important component of the overall management system for insects on hibiscus. By eliminating or reducing the use of broad-spectrum insecticides, the populations of predators may increase, allowing them to be more effective at regulating pest populations.

**g.** **Relationship to Other CRSP Activities at Site**: Results of biological analysis will be used as data for socio-economic evaluation of treatments.

**h.** **Progress to date:** Two years' data have been collected and will be analyzed when Mamadou Ndiaye visits Purdue in May, 2002. Progress will be determined at that time.

**i.** **Projected Outputs**: Determination of the best package for reduced pest damage and increased hibiscus flower yields.

**j.** **Projected Impacts**: Increased hibiscus production and increased farmer incomes.

**k.** **Start:** June 2001

**l.** **Projected Completion**: September 2003

**m.** **Projected person-months of scientist time per year**: 3-4 person-months.

**n.** **Budget**: IER/Sotuba – $6,710; OHVN – $720; University of Mali – $9,000; Purdue – $18,881

## III.1. Identification and management of tomato diseases

**a.** **Scientists** _Subactivity Leaders_: Aissata Traoré Théra, IER; Bob Gilbertson, UC-Davis. _Colloborating Scientists_: Kadiatou Touré Gamby, Haoua Traoré Sissoko, IER; Rick Foster, Purdue.

**b.** **Status**: Continuing activity.

**c.** **Objectives:** To specifically identify pathogens causing tomato yellow leaf curl and wilt diseases and to evaluate integrated pest management strategies for management of these diseases. To assess various methods to manage insects and insect-borne diseases and reduce insecticide usage on tomato.

**Objectives for coming year:** (1) Continue the characterization of the strain(s) of *Tomato yellow leaf curl virus* (TYLCV) infecting tomatoes in various tomato growing regions of Mali. (2) Evaluate a number of potential management strategies for TYLCV and whiteflies in field experiments. (3) Continue to identify wilt disease pathogens and begin to evaluate potential management strategies for the pathogen(s).

**d.** **Hypotheses:** (1) tomato production in Mali is being attacked by a strain or strains of TYLCV and possibly by other geminiviruses transmitted by *Bemisia tabaci*) or other viruses (e.g., aphid-transmitted viruses), (2) this pest complex can be managed by a combination of reflective mulches, a tomato-free period, insecticides and resistant host cultivars (3) diseases in Mali are caused by at least two different pathogens (*Ralstonia solanacearum* and *Pythium aphanidermatum*).

**e.** **Description of Research Activities:**

(1) Continue the characterization of the strain(s) of *Tomato yellow leaf curl virus* (TYLCV) infecting tomatoes in various tomato growing regions of Mali.

Partial characteization of the whitefly-transmitted virus(es) causing tomato diseases in the Baguineda and Bancoumana areas has revealed it is related to but genetically divergent from previously characterized strains of TYLCV. In order to further ascertain the nature of TYLCV-Mali, we propose to sequence additional portions of the viral genome. The nucleotide sequence of the cloned fragment(s) will be determined and compared to sequences of known TYLCV isolates. This will provide insight into the nature of the virus(es) involved in tomato yellow leaf curl in Mali. Cloned fragments of

TYLCV-Mali will be used as probes to investigate the distribution of the virus in selected tomato growing regions.

Samples of tomatoes and other plants with yellow leaf curl virus symptoms will be collected from various locations during survey trips conducted when the incidence of virus is high. Samples showing virus-like symptoms will be collected and tested for infection by TYLCV-Mali using squash blot hybridization and cloned TYLCV-Mali or a general geminivirus probe. This should indicate whether the cloned TYLCV-Mali DNA is representative of TYLCV in Mali or whether other geminiviruses (or other viruses are involves).

(2) Evaluate a number of potential management strategies for TYLCV and whiteflies in field experiments.

Based upon the results of the 2001-2002 plots, additional field plots will be established to evaluate the performance of the TYLCV-resistant variety Gempride in Mali. One plot will be at the experimental farm and the other in a village outside of Bamako. Treatments will be cv. Gempride or the standard Roma variety and treatment plots will be replicated. Plots will be monitored for whitefly populations, incidence of TYLCV and wilt and yield (number of tomatoes and fresh weight).

(3) Continue to identify wilt disease pathogens and begin to evaluate potential management strategies for the pathogen(s).

Based upon the results of the surveys conducted in 2001-2002, we will assess whether one or more pathogens appear to be the primary cause of wilt disease. Based on these findings, we will develop a number of disease management approaches that could be evaluated. Depending on the primary pathogen involved, these may be fungicide treatments to the soil, solarization of soil and/or resistant varieites. Field plots will then be designed to evaluate these management strategies.

Additional surveys will be conducted in tomato production areas during the rainy and dry seasons to further identify the causal agent(s) of wilt diseases in Mali. Representative plants will be samples and carefully examined for external symptoms (e.g., knots on roots [root knot nematode] or dark watersoaked discoloration of lower stem [Phytophthora/Pythium]) and internal vascular discoloration. A bacterial streaming test will also be performed on representative plants to look for bacterial wilt caused by *P. solanacearum*. Finally, a series of isolations will be performed in order to more precisely identify the fungi associated with the wilt disease problem.

f. **Justification:** Whitefly-transmitted geminivirus diseases have become limiting factors in tomato production in many parts of Africa, as well as the Middle East, Southern Europe, Asia, Central American, and the Caribbean. Wilt diseases and several aphid-transmitted viruses also can limit tomato production under conducive conditions. Many of these same diseases are either present or a potential threat to tomato production in both Mali and the United States. This complex has been reported to be limiting production of tomato in Mali. The emergence of this pest complex as a serious threat to tomato production is of concern to both Malian and U. S. scientists. Management of the problem is thus an appropriate focus for IPM CRSP research for periurban horticulture in Mali.

**g.** **Relationship to Other CRSP activities at Site**: Results of biological analysis will be used as data for partial budget analysis of treatments and ultimately lead to the development of an integrated package for tomatoes.

**h.** **Progress to Date:** Results for the 1999-2000 growing season are not yet available.

**i.** **Projected Outputs:** Identification of the best combination of practices to reduce damage due to the insect-transmitted virus disease complex of tomato under local conditions.

**j.** **Project Impacts:** Reduction of losses due to the insect/virus complex that is currently limiting tomato production in Mali, and increased income to farmers.

**k.** **Start:** October 1998

**l.** **Projected Completion**: September 2002

**m.** **Projected person-months of scientist time per year**: 3-4 person-months

**n.** **Budget**: IER/SotubA – $2,310; OHVN – $720; University of Mali – $9,000; UC-Davis – $11,082

## III.2. Management of Insect Pests of Tomatoes

**a.** **Scientists**: _Subactivity leaders_: Kadiatou Touré Gamby, IER; Rick Foster, Purdue; _Collaborating scientists:_ H.Traoré Sissoko - IER; Anthony Yeboah - North Carolina A & T.

**b.** **Status**: Continuing activity

**c.** **Objectives**: To evaluate the potential for using alternative management methods for insect pests of tomatoes.

**Objectives for coming year**: To continue evaluation of alternative management methods for insect pests of tomatoes, and to evaluate three new pesticides for the management of whiteflies.

**d.** **Hypotheses**: (1) The use of alternative pest management strategies will provide protection of one or more insects that is comparable to the use of broad-spectrum insecticides. (2) The use of systemic insecticides will kill whiteflies before they can transmit viruses that severely reduce tomato yields.

e. **Description of research activities**: Four treatments will be compared in 5 farmer's fields in each of six village in the OHVN and Baguineda zones. Virus susceptible varieties will be planted during the June planting period: (1) Control (no control measures); (2) Thiamethoxam (Platinum 2SC) at 96 ml/ha applied at emergence in seedbed and at transplanting; (3) Imidicloprid (Admire 2F) at 287 ml/ha applied at emergence in seedbed and at transplanting; (4) Mosquito netting to protect plants from whiteflies (from emergence to 3 weeks), applications of soap as needed to control aphids, applications of neem as needed to control caterpillars, and blue and yellow Vaseline covered traps to control aphids, whiteflies, and thrips. Counts will be made every 7 days of aphids, whiteflies, and thrips caught in the traps. At harvest, yield of harvested fruit will be determined. Percentage of plants showing symptoms of tomato leaf curl virus will be determined weekly beginning 3 weeks after emergence. Percentage of fruit damaged by caterpillars will be determined.

Similar studies will be conducted at the research stations at Sotuba and Beguineda. These studies will also include additional rates of the insecticides (60 and 96 ml/ha of thiamethoxam and 192 and 287 ml/ha of imidacloprid), changes in the timing of insecticide applications, and the efficacy of seed treatments. Studies at the research stations will include four replications each and will be arranged in a randomized complete block design.

Studies will be conducted at Sotuba and Baguineda to compare the relative susceptibility of several tomato cultivars. The varieties to be evaluated include GemPride (a virus resistant variety from Seminis), to virus resistant processing varieties from Heinz, and a local Roma variety. Data to be collected will include weekly whitefly counts, weekly estimations of virus symptoms, and yields.

**f.** **Justification**: Tomatoes are another important vegetable crop in Mali. A tomato processing plant is already in existence, so improvement in the ability to produce high quality tomatoes with little or no pesticide residues present would provide for development of tomatoes or tomato products as export commodities.

**g.** **Relationship to Other CRSP Activities at Site**: Results of biological analysis will be used as data for socio-economic evaluation of treatments.

**h.** **Progress to date**: Seedbed protection (with mosquito netting) of nurseries has decreased plant losses due to whiteflies as well as other pests (frogs). The package has proved beneficial in reducing losses due to pests.

**i.** **Projected Outputs**: Information on the effectiveness of a combination of alternatives to the current farmer practice of synthetic insecticide use.

**j.** **Projected Impacts**: Improvements in management of pest could result in higher yields, reduced pesticide costs and residues, and greater exportability of product.

**k.** **Start:** October 2000

**l.** **Projected Completion**: September 2003

**m.** **Projected person-months of scientist time per year**: 3-4 person-months

**n.** **Budget**: IER/Sotuba – $2,310; IER/Cinzana – $2,585

## III.3. Integrated Weed Control Strategies for Tomato Production

**a.** **Scientists**: Subactivity leaders:; Moussa N'Diaye, IER; Jim Westwood, Virginia Tech*;* Collaborating scientists: Bouréma Dembélé, IER; Kadiatou Touré Gamby; IER; Haoua Traoré Sissoko, IER.

**b.** **Status**: Continuing

**c.** **Overall Objective(s):** To develop integrated weed control strategies for periurban tomato production systems.

**Objective (s) for coming year**: (1) To continue experiments examining strategies for control of difficult weeds such as *Cyperus rotundus*: (a) hand weeding (b) herbicides (c) mulches, (d) burning residues, and (e) potash; (2) To determine the critical weed-free period for tomatoes; (3) To begin integrating weed control methods into a comprehensive vegetable production program.

**d.** **Hypotheses**: Supplementing hand weeding with weed control techniques such as herbicides and mulches can control *Cyperus rotundus* and reduce time needed for weed control operations. Many of the same broad spectrum weed control strategies under study for green bean production (mulches, potash, herbicides) are also appropriate for tomato culture.

**e.** **Description of Research Activity**: The techniques used for weed control in green beans should be equally effective for control in tomatoes. Since the pre-plant treatments under investigation for green beans are non-selective, they could be used before or after crop planting to maintain low weed density in rotational crops. Furthermore, the fact that tomatoes follow green beans as rainy season crop in the same garden plots means that good weed control during the tomato season will help prevent weeds during the green bean season and visa versa. Thus, the weed control techniques described in the green beans section will be investigated with respect to their efficacy in tomato as components of a total cropping system.

**f.** **Justification**: Weeds can cause significant yield reductions in tomato, both through direct competition for resources, and through the harboring of pathogens or pathogen vectors. *Cyperus rotundus* is one of the primary weeds of irrigated vegetables in the area around Bamako.

g. **Relationship to Other CRSP Activities in Mali**: This work will be coordinated with other periurban pest protection practices being developed under this project.

h. **Progress to Date**: Completed an inventory of problem weeds in tomato.

i. **Projected Outputs**: High yield of tomatoes with reduced labor expenditure through the efficient control of weed species in vegetable production systems. As the efficacy of the weed control strategies are determined, techniques will be incorporated into the curriculum of the Farmer Field Schools.

j. **Projected Impacts**: Improved weed control practices in tomato fields will increase yields, and hence grower revenue, through sale of produce. Achieving weed control with minimum inputs will keep costs down and maximize the profit from increased yield.

k. **Projected Start**: October 1999

l. **Projected Completion**: September 2003

m. **Projected Person-Months of Scientists Time per Year**: 2-3 person months

n. **Budget**: IER/Sotuba – $2,310; IER/Cinzana – $2,585; Virginia Tech – $192

### IV.1. Dissemination of Green Bean IPM Packages Through Farmer Field Schools

a. **Scientists**: *Subactivity leaders*: Kadiatou Touré Gamby; IER; Rick Foster, Purdue; Aissata Traoré Théra, Moussa Ndaiye, IER; Florence Dunkel, Montana State University; Issa Sidibé, OHVN. *Collaborating scientists*: Pat Hipkins, Virginia Tech; Bourema Dembélé, H.Traoré Sissoko, IER; Jim Westwood, Virginia Tech.

b. **Status**: Continuing activity.

c. **Objectives**: To develop an easy and simple strategy for disseminating the IPM technologies for periurban green beans, tomatoes, and hibiscus.

**Objective for the coming year:** To continue field testing a curriculum for Training Trainers (TOT) and farmers on IPM technologies for green beans and tomatoes adapting the Farmer Field School (FFS) methodology.

d. **Hypotheses**: The FFS approach permits the quick introduction, dissemination, and adoption of IPM technologies.

e. **Description of research activities**: The site is in Sanankoroba area within 50 kilometers of Bamako. The FFS will involve fifteen villages (three more than during the past year). Trainers will be IER and OHVN technicians. The trials for the TOT permit participants to have directed experiences implementing and monitoring crop production using IPM technologies and local farmer practices on a weekly basis. Technicians will play the role of trainers while working with the five farmers in each village who are collaborating in the on-farm trials (green beans or tomatoes). The FFS trials will consist of two plots (farmer practice and IPM) separated by two meters. The IPM plot will demonstrate the integrated package for green beans or tomatoes (in season). The Farmer Practice plot will include two waterings, use of mineral fertilizer, and the application of chemical for insect control. Technicians and farmers will compare the evolution of these two plots over the course of the growing season. Lessons in Pesticide Safety will be included in this program, as well as information on HIV/AIDS.

**f.** **Justification**: Research findings from Years 7 and 8 demonstrated that the IPM technologies for diseases, insects and weeds reduced pesticide use and pest damage. Experimentation with the Farmer Field School approach in Year 8 and 9 suggests that this method will improve the production of horticultural crops and speed the introduction and adoption of IPM technologies.

**g.** **Relationship to Other CRSP Activities at Site**: This activity is the result of previous and ongoing studies of green bean and tomato IPM technology components included in this study.

**h.** **Progress to date**: Preliminary results from Year 8 and 9 show promise for the speedy dissemination and adoption of IPM technologies. Separate and combined groups of men (103) and women (179) have been trained during the past year in twelve villages. Eleven peasant trainers (including two women) were used and several of those trained this past year will be used as trainers in the coming year.

**i.** **Projected Outputs**: Based on initial findings, we expect that increased numbers of growers will adopt this system of IPM techniques as a package that will result in greater yields, higher quality, less pesticide use, and greater returns.

**j.** **Projected Impacts**: Higher yields, lower pesticide costs and residues, reduced pest losses, more stable supply, and improved exportability of green beans.

**k.** **Start:** November 2000

**l.** **Projected Completion**: September 2003

**m.** **Projected person-months of scientist time per year**: 9-10 person-months

**n.** **Budget**: IER/Sotuba – $10,593; OHVN – $720; and Montana State – $5,418

### V.2 Promotion of Pest Management Practices by Female Farmers

**a.** **Scientists:** *Principal investigators*: Haoua Traoré Sissoko, Pende Sissoko Sow (IER) Colette Harris, Keith M. Moore (Virginia Tech), Anthony Yeboah (North Carolina A & T); *Collaborating scientists*: Mah Koné Diallo (OHVN)

**b**. **Status**: Continued Activity

c. **Objectives**: (1) To study the levels of adoption of IPM practices in green bean farming in communities in Mali. (2) To encourage women's usage of IPM techniques in the fields they farm and their support of their husbands to do the same in their own fields.

**d.** **Hypothesis**: Significantly increasing the participation of women in farming field schools and related activities, all within a gendered framework will produce fundamental changes in attitudes that will facilitate the adoption of IPM practices.

**e.** **Description of research activity**: (1) Separate farmer field schools established for women in the project villages will be continued and (2) the practices of the members of both men's and women's farmer field schools will be studied in relation to their acceptance of IPM practices in their own farming. These will be placed in the context of the practices of the other villagers who did not receive explicit training in IPM to see how the practices differ. The gender training for the present farmer field school agents and trainers will be continued.

**f**. **Justification:** Women in these parts of Mali have their own farming projects of green beans for market but have little technical information on farming. They did not receive much benefit from male farmers' field schools generally knowing nothing whatever about what was taught there. They are now reacting very positively to being included and this should make a significant difference in the adoption of IPM practices by the entire villages where the project is working.

**g**. **Relationship to other CRSP activities**: This project directly complements both the agronomical research and the male farmer field school activities already being carried out.

**h.** **Progress to date**: The addition of schools specifically for women during the 9$^{th}$ year has had a significant impact on the practices of the women included in them and continuing with this should have an even greater impact. The gender training carried out during the 9$^{th}$ year has already made some difference to attitudes towards including women in development projects on the part of IER and OHVN agents.

**i**. **Projected outputs**: (1) Women farmers using IPM techniques. (2) A report on the adoption of IPM practices by both men and women. (3) More gender sensitive men and women animators and farmer field school trainers.

**j.** **Projected impacts:** Increased adoption of IPM in the communities as a whole. Less damage to family health and the environment.

**k.** **Project start**: October 2001

**l**. **Project completion**: September 2003

**m**. **Projected person-month of scientist time**:

**n.** **Budget**: IER/Sotuba – $7,370; Virginia Tech – $5,427; OHVN – $360

## V.3 Strengthening Stakeholders in Periurban Export-Oriented Green Bean Production and Marketing

**a.** **Scientists:** *Principal investigators*: Kadiatou Touré Gamby (IER), Issa Sidibé (OHVN) Keith M. Moore (Virginia Tech), Anthony Yeboah, (North Carolina A & T). Collaborating scientists: Bouréma Dembélé, Moussa N'diaye, Moussa Noussourou, Mariam Diarra Diakité, Aissata Traoré Théra, Haoua Traoré Sissoko, Penda Sissoko Sow, (IER); Mah Koné Diallo, OHVN; Rick Foster, (Purdue); Florence Dunkel (Montana State University); Don Mullins, Pat Hipkins, Jim Westwood, (Virginia Tech).

**b.** **Status**: Continuing Activity

**c.** **Objectives**: To determine the strengths and weaknesses of IPM CRSP/Mali program activities in order to make adjustments improving the quality of IPM research and services delivered.

**Objective(s) for the coming year:** To provide an overview of green bean and tomato marketing and analyze alternative marketing channels and to determine how best to target quality assurance program activities.

**d.** **Hypothesis**: Improved understanding and coordination among green bean exporting stakeholders (farmers, exporters, researchers, extension agents, etc.) will increase the application of IPM practices, decrease rejection of exported crops, and improve incomes in the sector. In the OHVN zone, the major problem with production of green beans is damage from insect pests that leads to enormous production losses. Exporters wish to assure insect control with the use of the insecticide, Decis. However, the application of this chemical may reduce export market potential, and further, organically grown produce may command a higher market price. It is hypothesized that if farmers can control insect pests through non-chemical methods, then they can receive higher prices than they did for chemically produced produce.

**d.** **Description of research activity**: U.S. and Malian researchers and their OHVN and EQL colleagues are conducting discussions about how collaboration to improve the conditions for increased and profitable green bean exportation with green bean exporters working in the targeted villages. A case study approach will be used to gather information about price differentials between organically grown and conventionally grown green beans. The study will identify and explore who are the key players besides the economic operators (exporters) and the farmers, how produce is stocked, the importance of price and quality in grower-exporter-importer relations, seasonal variation in availability and market windows, problems exporters have with growers, cultivating cooperation among growers, creating a new organizational structure, standardizing the product, and standardizing packaging and labeling of produce.

e. **Justification:** Last year's Participatory Assessment and Gender Inventory Survey determined the prominent role exporters play in shaping farmer decision making concerning pest and pesticide management practices. Increased communication and understanding between exporters, researchers, extension agents and regulatory bodies will help to better integrate the sector facilitating the adoption of the most effective, profitable and safe pest management practices. The ability to sell their produce is key to sustaining the producers and exporters of Malian green beans. This work will help to realize the potential benefits of IPM CRSP bio-physical research.

f. **Relationship to other CRSP activities**: This activity will serve to confirm or provide the basis for adapting results from the biophysical experiments in the development of IPM technology packages for green beans, hibiscus and tomatoes. It will also reinforce work conducted by the quality assurance program.

g. **Progress to date**: A Participatory Assessment conducted this two years ago in the six target green bean producing villages demonstrated that farmers participating in IPM CRSP program activities were adopting improved practices. Changes in the planting date precipitated by the exporters unexpectedly disrupted the timing of research and outreach activities, however. Green bean growers, when presented with options are ready and willing to adopt improved IPM practices, such as the application of neem treatments in the place of the routine chemical pesticide (Decis) treatments. A major constraint for farmers is that payment for their crops is often late or is never made. Interviews with exporters this past year noted their concerns about price and quality monitoring issues at the point of entry of their produce in France. It also demonstrated the need for Malian producers to improve the market perception of their produce.

i. **Projected Outputs**: Improved dissemination of IPM technologies leading to more consistent quality and production levels in horticultural export crops. Increased quantity and quality of Malian green bean production marketed in Europe.

j. **Projected Impacts**: An IPM research and extension system that is more responsive to producer and agribusiness needs.

k. **Start**: October 2000

l. **Projected Completion**: September 2003

m. **Projected person-months of scientist time per year**: 4-5 person-months.

n. **Budget**: IER/Sotuba – $2,750; OHVN – $360; Virginia Tech – $6,704

## V.4 Economic (Partial Budget) Analysis of IPM Packages

**a.** **Scientists:** *Sub-activity leaders*: Anthony Yeboah, North Carolina A&T State University; Penda Sissoko Sow, IER. *Collaborating scientists:* Kadiatou Toure Gamby, IER; Moussa Nousourou, Mariam Diarra Diakite, Aissata Traore, Haoua Traore Sissoko, IER; Rick Foster, Purdue; Keith Moore, Pat Hipkins, Don Mulllins, Virginia Tech; and Issa Sidibe, OHVN.

**b.** **Status:** Continuing activity

**c.** **Objectives:** To determine the feasibility and profitability of the various treatments used in the trials with the aim of making recommendations to the producers.

**d.** **Hypothesis:** The adoption of IPM technologies will depend not only on their performance in the field but also on the costs and returns associated with them. More producers will adopt them if the technologies are cost effective and have positive monetary impact on the family.

**e.** **Description of research activities:**

In general, the analytic approach will consist of the following steps: (1) The development of partial budgets for each treatment; (2) The identification of "superior" treatments (dominant analysis) in terms of the highest profitability to justify adoption by producers; (3) The calculation of marginal rate of profitability for each "superior" treatment using benefit-cost analysis; (4) Choice of treatment based on farmers' ability to apply them. Sensitivity analysis will also be conducted.

Economic analyses have been conducted on the results from agronomic trials from two cropping season. Analysis for the third year is still in progress. Once completed, an overview of the three-years' work will be conducted to consolidate reasons for technological choice. This will form the basis for the formulation of a recommendation policy. Potential for adoption among the farmers will be assessed and intermediate impact indicators developed.

**f.** **Justification:** The on-going emphasis on farming systems research has reinforced the role of on-farm agronomic trials in developing appropriate technologies for farmers' use. However, statistically significant performance of a particular technology does not always translate into economic benefits to its user. Agronomic efficiency does not always entail economic efficiency. It is therefore necessary to analyze how agronomic benefits translate into socio-economic benefits since these ultimately determine the adoptability of the proposed technology.

**g.** **Relationship to Other CRSP Activities at Site:** This year's technologies are being tested as a "package" rather than in subsets. The economic analysis will take into account the complexity this brings

**h.** **Progress to date:** The most progress has been made on economic analysis of insect control trials on green beans. The results of the economic analysis indicates that the use of insect traps yields a net profit of 1,641,532 FCFA or $2,345 per hectare (US$1= 700 FCFA) while the use of insect traps plus the application of neem leaf extract yields 1,640,664 FCFA or $2,344 per hectare. Both figures are slightly higher than the corresponding figures for the farmer's practice of three applications of Decis, plus an application chemical fertilizer and organic manure. This implies that the use IPM technologies can lead to the production of wholesome green beans without sacrificing income to the farmers. The profitability for single and double applications of Decis were not significantly higher than those from the IPM packages: 1,719,462 FCFA ($2,456) and 1,703,642 FCFA ($2,434) per hectare respectively. Hence there is no economic reason for the farmers to use chemical methods of insect control.

**i.** **Projected Outputs:** This year's work will lead to a consolidation of information about the use of yellow traps in insect control on green beans. The IPM package that includes the use of yellow traps is expected to remain the most cost-effective mode of insect control on green beans. A risk analysis of this IPM technology will provide insight to the variability of performance among farmers. This will involve the calculation and comparison of the variability of added benefit per hectare, marginal rate of return and other economic indicators from the use of yellow traps. This process will allow for the grouping of farmers. The characteristics and unique attributes of each farmer will then be noted.

**j.** **Projected Impacts:** The potential for adoption by farmers in the research area will be known and together with farmers' typology already in existence at OHVN, the overall adoption level by farmers and potential impact on household can be ascertained. Specific intermediate impacts indicators will include the number of farmers using the yellow traps, the total crop area of application, quantities of green beans produced and sold and the resulting income generated. It is expected that the increased use of yellow traps will lead to the production of wholesome green beans that will meet the health and nutritional requirements of importing countries.

**k.** **Start:** October 1998

**l.** **Projected Completion:** September 2003

**m.** **Projected person-months of scientist time per year:** 3 person-months

**n.** **Budget (2002-03):** IER/Sotuba – $9,350; North Carolina A&T – $15,726

## VI. Development of Quality Assurance Program for Periurban Horticulture Crops

**a.** **Scientists**: *Subactivity leaders:* Mme Halima Traoré – LCV/Toxicology; Jean Cobb, Pat Hipkins, and Don Mullins – Virginia Tech. *Collaborating scientists:* Mme Safiatou Dem, Mme Habiba Maïga – LCV/Toxicology; Harold McNair – Virginia Tech, Mme Kadiatou Gamby – IER, Issa Sidibé – OHVN.

**b.** **Status**: Continuing activity.

**c.** **Objectives**: To provide technical laboratory support to the LCV Toxicology Laboratory and pesticide safety education to village farmers via IER and OHVN trainers in the periurban horticultural crop region of Bamako.

**Objectives for coming year**: (1) Develop methods for pesticide residue analysis of horticultural crops based on Malian laboratory conditions; (2) Provide training on the use and maintenance of laboratory equipment and instrumentation; (3) Work with a Malian scientist who will begin M. S. graduate studies in environmental chemistry at Virginia Tech in Fall 2002; (4) Provide training in pesticide safety education to IER and OHVN field technicians, so they may provide training to Malian growers; (5) Develop additional pesticide safety education lessons and materials; (6) Help to provide sustainable sources of equipment for pesticide application and safe handling for grower use; (7) Evaluate the quality of water used for pesticide applications; and (8) Facilitate a proactive approach towards pesticide residue testing of Malian crop exports destined the European Union.

**d.** **Hypotheses**: (1) Developing methods for pesticide residue analysis that minimize the use of chemicals/solvents fosters sustainability; (2) Continued training on the use and maintenance of equipment and instrumentation builds professional capabilities and increases the functionality of the laboratory; (3) Training a graduate student in environmental chemistry will extend the capabilities of the LCV Toxicology Laboratory and provide useful information on pesticide residues in the environment; (4) A pesticide safety education program will help to ensure that horticultural crops meet export standards while promoting personal and environmental safety; and (5) Additional pesticide safety lessons and program support materials will meet the needs of IER's expanding Farmer Field School program; (6) Sustainable sources of safety and application equipment will protect human health; (7) Both application technology and water quality affect pesticide efficacy, and preventable pesticide failures may lead to misuse and overexposure; and (8) A proactive approach towards pesticide residue testing of crop exports will allow pesticide safety educators to inform farmers before problems occur and will allow the LCV to implement crop testing efficiently in stages.

**e.** **Description of research activities**:

(1) Develop laboratory methods at Virginia Tech for potential use in Mali and provide written documentation of the results for evaluation at the LCV Toxicology Laboratory. During the annual training session at Virginia Tech, evaluate methods for pesticides in

crops not tested under Malian laboratory conditions due to lack of chemicals and glassware.

(2) Continue training on the use and maintenance of equipment and instrumentation both at the LCV Toxicology Laboratory and at Virginia Tech during the annual training session. This year, training will focus on use and maintenance of the high performance liquid chromatograph (HPLC), carbamate and acid herbicide derivitizations for gas chromatography, and other method development as needed.

(3) Assist a graduate student who will move to Blacksburg in May 2002. The student will attend both summer sessions at the English as a Second Language Institute in preparation for the TOEFL exam. Mentor the student through the academic year beginning in Fall 2002 in a Master's Degree in environmental chemistry that will involve the study of pesticide residues in soil and water.

(4 and 5) Revise initial series of eight pesticide safety lessons if/as needed, based on comments IER trainers and farmers. Write additional lessons to address interests and needs identified by IER trainers during January 2002. Present new lessons to IER field agents. Include new groups of trainers and other cooperators. If/as relevant, include information from EQL lab regarding residue detections. Through IER and other trainers, deliver lessons to a wider audience. Develop a pesticide safety 'flip chart' similar to one used to teach farm workers in the U.S.

(6) Contact export agents, professional organizations (AMELEF, APEFEL), and CAE to encourage them to provide appropriate pesticide safety and application equipment to growers.

(7) Conduct water quality tests (pH, conductivity, turbidity), and evaluate the effects of water quality on pesticide efficacy.

(8) Continue to meet with private organizations and government institutions involved in the export of horticultural crops. Our goal is to facilitate communication and assist in defining a role for pesticide safety education and laboratory expertise in a quality assurance program for export crops.

f. **Justification**: The LCV Toxicology Laboratory has a comprehensive mandate, which includes pesticide residue analysis of horticultural crops and environmental monitoring. The development of cost effective pesticide residue methods and a thorough familiarity with the use and maintenance of laboratory instrumentation are important components in fulfilling this mandate. In addition, environmental studies by a Malian graduate student will expand the capabilities of the laboratory and has the potential to provide useful data about pesticides in Malian soil and water. Additional pesticide safety lessons for IER and OHVN trainers and other cooperators strengthens the information network and helps to improve safety and adoption of IPM technology at the village level. Development of multilingual (French and Bamenan) 'flip charts' provides additional teaching materials for reaching farmers at the village level. Facilitating a proactive approach to quality assurance of horticultural export crops, through pesticide safety education and pesticide residue testing, promotes higher quality export crops to European and U. S. markets.

g. **Relationship to other CRSP activities at site**: Pesticide safety teaching materials will assist IER and OHVN agents who train growers in Farmer Field Schools and will assist in improving the knowledge base at the village level. Laboratory technical capability in pesticide residue analysis will assist IER field researchers in selecting IPM practices that improve the quality of crops destined for European and U. S. markets.

h. **Progress to date**: Training in pesticide residue analysis (techniques and use of equipment and instrumentation) continues to enhance the capabilities of the LCV Toxicology Laboratory. Assistance in obtaining electrical stabilization equipment (voltage regulators and battery backups) allows a new level of protection for delicate chromatography instrumentation and computers. Gas chromatograph/mass selective detector analysis at Virginia Tech of formulated pesticides purchased from Bamako vendors provided useful information about the purity of pesticides available on the market. Pesticide safety lessons were delivered to IER researchers and field staff. Pesticide safety education is now a component of IER's FFS curriculum.

i. **Projected outputs**: Pesticide residue analysis conducted at the LCV will assist IER research scientists and others involved in crop quality assurance. Training a M.S. student in environmental chemistry expand the current capabilities of this laboratory. Pesticide safety education will support Malian efforts to produce crops for export and local markets while protecting human health and the environment.

j. **Projected impacts**: Pesticide residue testing and pesticide safety education will result in front-end quality control of horticultural crops exported to European and U.S. markets. Assistance to the crop export industry will benefit the Malian economy. Adoption of best management practices for pesticides will protect growers, consumers and the environment.

k. **Start:** January 1999

l. **Projected completion**: June 2005

m. **Projected person-months of scientist time per year**: 36 person-months.

n. **Budget (2002-03)**: EQL/LCV – $31,799; Virginia Tech – $67,459

## VII.1 Innovative Techniques for Striga Management

a. **Scientist(s)**: <u>*Subactivity leaders*</u>: Bouréma Dembélé, IER; Jim Westwood, Virginia Tech. <u>*Collaborating scientists*</u>: Mountaga Kayentao, IER; Daouda Dembélé, IER; Mme. Gamby Kadiatou Touré; Mme. Sissoko H.T., IER;

**b**. **Status**: Continuing

**c**. **Overall Objective(s)**: *Striga* is one of the primary limitations to cereal production in sub-Saharan Africa. Our objective is to identify new strategies for *Striga* control that can be incorporated into an integrated pest management program for protecting sorghum and millet from devastation by *Striga*. The specific area we are working on is the use of herbicidal control methodology that employs seed coating, a familiar concept to most farmers and one that requires low investments of time and resources.

**Objective (s) for coming year**: (1) To confirm results of previous year's research and refine methodologies for herbicide seed treatments for controlling *Striga* in sorghum and millet. (2) To begin incorporating herbicide seed treatments with other components of an integrated control program. (3) To continue studies of mechanisms of *Striga* resistance in selected sorghum lines. (4) To submit two papers for publication.

**d**. **Hypotheses**: (1) Coating seeds of sorghum and millet with selective herbicides will protect crops from early parasitization by *Striga*. (2) Combining herbicide use with crop varieties having some resistance to *Striga* will significantly increase yields. (3) Understanding mechanisms of *Striga* resistance in sorghum will support efforts to generate resistant crop varieties.

**e**. **Description of Research Activity**: Research will build on previous work that indicated the potential of herbicide seed treatments to prevent parasitism early in the life of the crop. Initial laboratory studies identified five candidate herbicides with selectivity in sorghum and millet. Subsequent field tests with these herbicides indicated that 2,4-DB showed promise in reducing *Striga* emergence on sorghum and increasing yield. Data has now been gathered over three field seasons, although variations in weather has complicated confirmation of results. Additional experiments will be performed as needed to verify findings and fill in gaps in the data. Emphasis will shift from field research to experiments conducted in pots and hydroponic bags, which offer more control over growing conditions for both host and parasite. Experiments will continue to characterize mechanisms of *Striga* resistance in locally selected sorghum lines using the hydroponic bag system. Such analysis will specifically compare selected resistant lines to susceptible lines in terms of stimulant production, resistance to *Striga* penetration, and growth of *Striga* following successful attachment.

**f.** **Justification**: The participatory assessment conducted in July 1994 and the farmer evaluation of 1996 indicated that *Striga* was one of the two highest priorities for farmers of millet and sorghum. The impact of *Striga* will only be diminished by sustained integrated control efforts, all of which contribute to control of the weed. Among the most effective and appropriate strategies are those aimed at increasing host resistance to *Striga*. In addition, new approaches to herbicide application have shown promise in recent years for control of *Striga*, and the proposed research seeks to combine these strategies in order to provide an effective integrated control program.

g. **Relationship to Other CRSP Activities in Mali**: This work will be compared to other *Striga* control practices (intercropping) developed during Years 1-6. *Striga* is also a major problem at the Uganda IPM CRSP site and research on this approach to *Striga* control is being coordinated with Uganda site counterparts.

h. **Progress to date**: Results from the sorghum study indicated that seeds soaked in a 0.5% solution of 2,4-DB for five minutes resulted in plants that were parasitized significantly less ($P<0.05$) than control plants. Additional research on this compound indicates that the seed treatment has a positive effect on reducing parasitism by *Striga*, although the effects occur early in the growth of the host and higher rates may result in toxicity to the sorghum or millet. Confirmation of results and experiments to refine application methodology to take advantage of the beneficial effects while minimizing risk of crop injury are continuing. Studies of *Striga* resistance in sorghum cultivars in the laboratory have been underway for one year. During this time several obstacles to growing sorghum in the polyethylene bag system have been overcome, and at least two different mechanisms appear to be operating in different varieties, one based on low stimulant production from the host, and another occurring after parasite attachment.

i. **Projected Outputs**: Data will be generated on the efficacy of a new strategy for inclusion in integrated *Striga* management programs. Researchers at IER will have increased capacity for answering important research questions about sorghum and millet interactions with *Striga*. A manuscript will be prepared based on data from herbicide seed treatment experiments.

j. **Projected Impacts**: *Striga* infestation will be reduced with minimal pesticide use, allowing farmers to obtain greater yields and enabling them to meet subsistence needs with more surplus available for market sale, thereby contributing to transition from largely subsistence-based production to mixed subsistence-market based production.

k. **Projected Start**: October 1998

l. **Projected Completion**: September 2003

m. **Projected Person-Months of Scientists Time per Year**: 2-3 person months

n. **Budget**: IER/Sotuba – $4,785; Virginia Tech – $5,555

Summary of Tenth Year Work Plan Activities for the West Africa Site in Mali

| Activity | | Activity Leaders | Year | | | | | Total Activity Budget |
|---|---|---|---|---|---|---|---|---|
| | | | 6 | 7 | 8 | 9 | 10 | |
| I. IPM in Green Beans | | | | | | | | |
| 1 | Disease Components | | X | X | X | | | |
| 2 | Insect Components | | X | X | X | | | |
| 3 | Weed Components | N'Diaye, IER; Westwood, VT | | X | X | X | X | 12,331 |
| 4 | Integrated Package | | | | X | X | | |
| II. IPM in Hibiscus | | | | | | | | |
| 1 | Insect Components | | X | X | X | | | |
| 2 | Weed Components | | | | X | X | | |
| 3 | Integrated Package | Gamby, Noussourou, Dembélé, IER; Foster, Purdue; Westwood, VT | | | | X | X | 35,311 |
| III. IPM in Tomatoes | | | | | | | | |
| 1 | Disease Components | Diakité, Théra, IER; Gilbertson, UC-Davis | | X | X | X | X | 14,112 |
| 2 | Insect Components | Gamby, IER; Foster, Purdue | | X | X | X | X | 13,895 |
| 3 | Weed Components | N'Diaye, IER; Westwood, VT | | X | X | X | X | 5,087 |
| 4 | Integrated Package | | | | X | X | | |
| IV. Farmer Field School | | | | | | | | |
| 1 | Dissemination of IPM Packages | Gamby, Théra, N'Diaye, IER; Foster, Purdue; Dunkel, MSU | | | | X | X | 16,731 |
| V. Socio-Economic Analyses | | | | | | | | |
| 1 | Gender Inventory | | | | X | X | | |
| 2 | Promotion of Pest Management Practices | Sissoko, Sow, IER; Harris, Moore, VT; Yeboah, NCAT | | | | X | X | 13,517 |
| 3 | Strengthening Stakeholder Relations | Gamby, IER; Sidibé, OHVN; Moore, VT; Yeboah, NCAT | | | X | X | X | 9.454 |
| 4 | Partial Budget Analyses | Yeboah, NCAT; Sow, IER | | X | X | X | X | 29,076 |
| VI. Developing a Quality Assurance System | | | | | | | | |
| 1 | Technical Support to EQL and PSE | Traoré, EQL; Cobb, Hipkins, Mullins, VT | | X | X | X | X | 99,258 |
| 2 | Linkages with IPM Field Research | | | | X | X | | |
| VII. Striga Management | | | | | | | | |
| 1 | Innovative Techniques for Striga Management | Dembélé, IER; Westwood, VT | X | X | X | X | X | 10,340 |

# Year 10 Work Plan for the Eastern Africa Site in Uganda

Year 10 IPM CRSP activities at the African Site in Uganda will focus on five topical areas. First, research activities to refine and disseminate development of IPM packages for important legume (cowpea and groundnuts) and cereal crops (maize and sorghum) with transition farming systems in Eastern Uganda will be concluded. Second, the development of IPM packages for the high-value horticultural crop, tomato, will continue. 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. Third, in order to develop appropriate post-harvest management options to reduce the incidence of moulds and mycotoxins on maize and groundnuts, work will continue on determining harvesting, drying, shelling and storage regimes of these commodities at both the farm and market. Fourth, socioeconomic assessment activities will evaluate the farm level economic impacts of IPM packages on maize, cowpea and groundnut; assess factors influencing the adoption of IPM CRSP packages for groundnuts, sorghum and cowpea; analyze the tomato marketing systems; and, assess extension agent knowledge of pest management and IPM as a way to further disseminate IPM and IPM CRSP recommendations. The proceedings of an IPM CRSP Symposium to be held in Uganda during Year 9 will also be assembled and published and additional regional participation pursued. Finally, an affiliated activity with funding from USAID/Kampala and the IPM CRSP Management Entity (ME) that is investigating the etiology, epidemiology and integrated management of coffee wilt (*Fusarium xylariodes* (telemorph=Gibberella xylarioides), will be concluded.

The IPM CRSP research team in Uganda is composed of scientists from each of the major research institutions located in the country including Makerere University's Faculty of Agriculture, and the three research institutes associated with the National Agricultural Research Organization (NARO): Kwanda Agricultural Research Institute (KARI), Namulonge Agricultural Research Institute (NARI), the Serere Agricultural and Animal Research Institute (SAARI), and the Coffee Research Institute (CORI). On-farm research activities are facilitated by extension agents and farmer associations at research sites in Iganga, Kumi, Mpigi and Pallisa districts. Also, there are four Makerere University graduate students contributing to field research efforts. Three Ugandan graduate students will complete their course training in the USA.

The eight collaborating research scientists from the USA are drawn from three institutions: Virginia Tech, The Ohio State University and Fort Valley State College. This multi-disciplinary and institutional effort is coordinated by the Site Chair located at The Ohio State University; the Site Coordinator located at Makerere University and the Deputy Site Coordinator located at NARI. Additional institutions contributing to the IPM CRSP research effort in Uganda are the Rockefeller Research Forum, and the International Center for Insect Physiology and Ecology (ICIPE). Four of the IARCs are participating through germplasm contributions including IITA, CIP, ICRISAT and CIMMYT/Harare.

## I. High Commercial Value Legume Crops associated with High Pesticide Use.

Activities in this section focus on cowpea and groundnuts that are important food security and cash crops in Eastern Uganda. The production of each of these crops is associated with frequent and often excessive use of synthetic pesticides.

### I.1.1 Integrated Management of Cowpea Insect Pests and Diseases

**a.** **Scientists**: E. Adipala; S. Kyamanywa; W. Ekere; P. Kibwika - Makerere University; G. Luther and H. Warren - Virginia Tech.; J. Mbata - Fort Valley ***State*** University, USA; G. Epieru, A. Agona, NARO; V. Odeke, DAO's Office, Kumi; E. Iceduna, DAO's Office, Pallisa; R.B Hammond and M. Erbaugh - Ohio State; Okoth, Graduate and ***Undergraduate*** students - Makerere University

**Collaborators**: Rockefeller Foundation (Forum) [cost sharing on M.Sc. student for local networking and scaling-up].

**b.** **Status**: Continuing research with new activities.

**c.** **Objectives**: The overall objective is to reduce and rationalize pesticide usage on cowpea in Eastern Uganda. The specific objectives are: (1) to scale-up dissemination of IPM technologies; (2) to refine IPM options by (a) to integrate synthetic and biorationals for management of field pests and bruchids (b) to validate EILs and action thresholds of flower thrips, aphids and pod borers to guide insecticide application on-farm; (3) to determine the effectiveness of predators and parasitoids of cowpea insect pests, (4) to determine the efficacy of pheromone baited trapping and use of parastoids in the management of cowpea beetles (*Callosobruchus* spp.) in the field.

**d.** **Hypotheses**: (1) An IPM strategy, involving close spacing, early planting and strategic insecticide application based on will control cowpea pests. (2) Integration of synthetics and biorationals is beneficial in the management of field pests and bruchids. (3) There is a level of population density below which thrips, aphids and podborers do not cause yield loss in cowpea. (4) There are predators and parasitoids that exert significant biological control pressure on some major insect pests of cowpea in Uganda. (5) Pheromone trapping will and parasitoids eliminate or reduce populations of cowpea bruchids.

**e.** **Description of Research Activity**: This activity is subdivided into four sub- activities:

<u>Dissemination and adoption of IPM technologies</u> (*continuing activity*) [Adipala-Ekwamu S. Kyamanywa, R. Hammond and M. Erbaugh]. The three most promising IPM technologies recommended for cowpea pests (***Aphis craccivora, Megalorothrips sjostedti, Clavigrara sp. and Maruca sp.)*** and diseases evaluated in year 9 will continue to be evaluated and disseminated using a modified farmer field school approach with two groups of farmers in Kumi and Pallisa districts. The treatments to be incorporated into the field design are; IPM 1, close spaced sole cowpea (30 x 20cm) and 3 sprays (once at budding, flowering & podding stages); IPM 2, cowpea/sorghum intercrop and 3 sprays; IPM 3 close spaced sole cowpea (no spraying) and the farmer traditional practice of

spraying ***pesticides*** 5 times, starting 10 days after emergence. With each farmer group a demonstration trial using a randomised block design with 2 replications will be established. Individual treatments will be on10 m. by 10m plots. Field monitoring of pests and diseases will be conducted with farmers every two weeks following seedling establishment. Data on pest and disease incidence and yields will be collected and discussed with farmers. Additionally, a cost-benefit analysis will be carried out to determine the profitability of the IPM packages.

Refining of IPM [Adipala-Ekwamu; S. Kyamanywa; A. Agona; R.B. Hammond, G. Luther and Opolot, H.N. (Okoth, MSc. Student)] (*continuing activity*). A second study will validate and incorporate EIL for thrips and action thresholds and, control of post-podding pests and bruchids using biorational products (crude extracts of tobacco, tephrosia and tagetes. Randomized block design trials with 4 replications will be established at two locations in Kumi and Pallisa districts in eastern Uganda. Individual treatments will be on 6 m. X 6 m plots. Treatments will include the following: IPM 1, sole crop cowpea sprayed 3 times with a synthetic pesticide at budding, flowering and podding; IPM 2, spray at budding, a second spray (synthetic) depending on EIL (for thrips) at flowering, and third spray at podding; IPM 3, spray at budding, second spray (synthetic) at flowering, and third spray with botanical product at podding; IPM 4, spray at budding, a second spray (synthetic) depending on EIL (for thrips) at flowering; and third spray with botanical at podding. Fields will be monitored through out the growing season. The effect of botanicals on predators and other beneficial insects at the budding, flowering and podding stages will be determined. The economic aspects of these alternatives will also be evaluated.

Determine effectiveness of predators and parasitoids of insect pests on cowpea (S. Kyamanywa, G. Luther, R. Hammond and T. Munyuli (MSc. Student).

Predators. Effectiveness of predation of *Coleomagilla* (Coccinellidae) will be tested *on Aphis craccivora.* Depending on availability, spiders and earwigs may also be tested as predators of aphids. Cage experiments will be set up in the field with these predator and pest species combinations to determine predation rates. Cages will be infested with a known number of predator species along with individuals of the pests species to be tested. Counts of living prey and predators will be made daily for the first 5 days, henceforth every other day until all prey are killed and consumed. Each combination of predator species and pest species will be replicated 5 times. Unknown predator species will be sent to a specialist for identification. Predator populations will be sampled in the pesticide free field described below in part b to determine their abundance and diversity in this situation.

Parasitoids. Cowpea pests will be sampled in the field to determine parasitism rates. In order to determine parasitism rates in a pesticide-free situation, cowpea will be planted in field isolated from pesticide treated fields to eliminate effect of drift and runoff on pest and parasitoids. Major cowpea pests will be sampled once per week from this field and reared in the laboratory to determine parasitism rates. All parasitoids will be identified at least to the family level and the unknown ones will be sent to a specialist for identification to species.

Field management of Cowpea bruchids (Callosobruchus sp.) using parasitoids and pheromones [G. Mbata, A. Agona, S. Kyamanywa, R.B Hammond].

Use of parasitoids (new activity). The parasitoids, *Anisopteromalus calandrae* and *Pteromalus cereallela* will be evaluated for control of cowpea seed beetle *(M. chalcosma*) in the field. Cowpea plots will be established in two sites (Kabanyolo and Kawanda). Cages will be used to contain the introduced parastoids unto the crop and will be placed in the crop a week before introducing the parastoids. The experiment will comprise of six treatments: controls (open field and caged plants with no parasitoids released), and other treatments with parasitoids released at 50% podding, pod filling, full podding and harvest maturity stages. The treatments will be replicated four times. The parasitoids to be used in this study will be from laboratory routine stock cultures. At least a minimum of five hundred parasitoids will be released for every treatment. Bruchids damage on cowpea, and *number of* parasitoid adults will be compared for the treated and control plots.

Use of pheromone baited traps. Cowpea plots will be established in two locations at Kawanda and Kabanyolo. An uncultivated plot will separate the plots. This is to minimize migration from control plot to plot dispensed with pheromone. Rubber septum will be used exclusively to dispense the pheromone. The rubber septum will be placed in *Pherocon II* diamond sticky traps. The traps containing the pheromone will be hung on pegs at the height of cowpea pods at pod filling stage. The traps will be set up at intervals of 3 m across the length and breadth of the plot. The plot will measure 50 x 50m. The pheromone septa will be replaced every week. The insects caught in the trap will be counted every week as the septa are changed. The level of infestation will be compared with that of the control that will not have traps dispensed in them.

f. **Justification**: Cowpea is the third most important legume crop in Uganda but a multitude of insect pests and the low yield potential of the local cultivars seriously curtail yields. Occasionally, diseases, especially yellow blister disease, also cause significant losses. Under previous IPM/CRSP activities promising technologies for management of cowpea pests have been developed, validated, disseminated and adopted by a few farmers. This activity needs up-scaling to reach more farmers, by establishing field schools and interacting with other partners. Studies carried out in year 9 to determine economic injury levels (EIL) and action thresholds need to be continued in year 10 for confirmation of results at farm level. Likewise, studies on predators of cowpea insect pests need to be continued in year 10 and be integrated with IPM options. We need to better understand the efficacy of predators and parasitoids of cowpea pests to fully utilize these natural control agents in an IPM system. Better understanding of their biology and ecology may help us to enhance biological control in the Ugandan cowpea agroecosystem.

g. **Project output:** Recommendations on rational use of pesticides and non-chemical measures for managing cowpea pests identified, tested and disseminated. EILs established to guide pesticide usage, and knowledge of beneficial fauna and biorationals will be incorporated into the IPM packages. Pamphlets will be produced for disseminating research results. A broader cowpea germplasm base will be created for use by the cowpea-breeding program at SAARI.

**h.** **Project Impact**: (1) Reduced usage of pesticides. (2) Reduced cost of production and increased yield of cowpea in Uganda. (3) Incorporation of EILs on cowpea pest management (4) A broader cowpea germplasm base for both spinach and grain production in Uganda. (5) Enhancement of human capacity for research through student training (6) Stronger collaboration and new opportunities for networking among participating institutions.

**i.** **Progress to Date:**

- Validation of IPM technologies,has been completed, and the student has graduated. The proven IPM technologies are the ones being disseminated through the modified farmers schools which started in year 9 and they will be continued in year ten.
- EILs for cowpea thrips have been established and are being integrated in IPM packages. So far one seasons data has been collected in year 9 and will completed in year 10 A Student will graduate in 2003.
- A survey was conducted which provided a profile of beneficial arthropods in eastern Uganda agroecosystems and the performance of introduced cowpea lines were evaluated; these activities are ongoing for two additional season.
- Ten new cowpea varieties have been recommended for advanced testing by the cowpea breeding program at SAARI.

**j**. **Started**: September 2001

**k.** **Project Completion**: September 2003

**l.** **Projected Person-Months of Scientist Time per Year**: 3 months

**m**. **Budget for 2001/2002**: Makerere University – $14,060; Virginia Tech – $2,937; and Fort Valley University – $8,450; OSU – $3,780

### I.1.2. Integrated Management of Groundnut Insect Pests and Diseases

**a.** **Scientists:** E. Adipala; S. Kyamanywa, A. Kaaya - Makerere University; G. Luther and H. Warren - Virginia Tech, USA; A. Agona - NARO/KARI, G. Epieru - NARO/ SAARI; V. Odeke-DAO's Office, Kumi; R.B. Hammond and M. Erbaugh - Ohio State. Graduate (Mr. T. Munyuli) and Undergraduate Student - Makerere University

**Collaborators**: NARO-DFID (cost-sharing on MSc. student training, local networking for scaling-up)

**b.** **Status:** Continuing research with new activities.

c. **Objectives:** The broad goal is to develop integrated disease and pest management packages, including post-harvest packages, for groundnuts. Specific objectives are: (1) To validate and disseminate IPM packages; (2) To assess the effect of different insecticides on predators and parasitoids; (3) To determine economic injury levels and action threshold levels for leaf miners and thrips.

d. **Hypotheses:** (1) An IPM strategy, involving early planting, close spacing, rosette resistant varieties and minimum spray schedule (2-3 sprays of Dimethoate or 1-2 sprays of both Dimethoate and Dithane M45) will reduce the incidence of rosette and severity of Cercospora leaf spots diseases of groundnut; (2) Different insecticides exert the same level of mortality on predators and parasitoids; (3) There are predators and parasitoids that exert significant biological control pressure on some of the major insect pests of groundnuts in Ugandan; (4) Leaf miners, thrips and foot rot reduce groundnut yields in Uganda; (5) Suggested IPM packages are effective against rosette and Cercospora leaf spots and are economical.

e. **Description of Research Activity**:
This is an on going activity which is divided into three sub-activities: In all the trials, Rosette incidence and Cercospora (*Cercospora arachidicola*) severity will be assessed based on the scale used by Adipala *et al*. (1998) and the nine point model by Subrahmanyam *et al*. (1995), respectively. Leaf miner (*Aroarema modicella*) damage will be assessed based on a score scale of 1 - 3; where 1 equals <20% damage; 2 equals 20-50% damage; and 3 equals >50%. Foot rot (*Sclerotium rolfsii*) damage will be assessed based on the incidence of the disease per two center rows of each experimental unit. Thrips (*Thrips palmi* Karn, *Frankliniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus*) infestation will be assessed at a weekly interval starting at budding stage based on 20 flower buds /flower per experimental unit, depending on the crop growth stage. Aphid infestation will be assessed based on a scale of 1-5, where 1=no aphids, 2= >10 aphid/plant, 3= 10-50 aphids/plant, 4=>50-100 aphids per plant and 5= >100 aphids per plant.

<u>Validation and dissemination of IPM packages</u>. [E. Adipala; S. Kyamanywa - Makerere University; H. Warren-Virginia Tech, USA; G. Epieru-NARO/SAARI; R. Hammond and M. Erbaugh-Ohio State. IPM packages developed for groundnut pests and diseases and evaluated in year 9 will be evaluated by 3 groups of farmers (10 per group) in Kumi and Iganga districts. The treatments will include the farmers' practices (FP), calendar sprays (CS), and the improved practice (recommended by Mukankusi et al., 2001), i.e., early planting, close spacing (30 x 10 cm) and a minimum spray schedule of 2 Dimethoate. Joint farmer-scientist evaluations of the trial will continue. Additionally, cost-benefit analysis will be carried out to determine the profitability of the IPM packages.

<u>Impact of Predators and Parasitoids of Major Insect Pests on Groundnut</u>. [S. Kyamanywa; E. Adipala, - Makerere University; G. Luther - Virginia Tech, USA; G. Epieru-NARO/SAARI; R. Hammond - Ohio State; Theodore Munyuli - Makerere University].

<u>Assessment of the effect of different insecticides on major parasitoids and predators</u>**.**

Six commonly available insecticides at their recommended spray rates will be evaluated for their impact on mortality rates of groundnut parasitoids and predators. Parasitoids and predators populations will be monitored and major groundnut pests will be sampled and yield data recorded. The chemical treatment will also include a fungicide, Dithane M45, which will be used to control Cercospora leaf spot. The trial will be a completely randomized block design and replicated four times. Treatment plots will be 6m. by 6m. The study will be conducted at TVC at Kumi.

Effectiveness of Predators. Effectiveness of predation of Staphylinidae will be tested on *Aphis craccivora.* Depending on availability, ants may also be tested as predators of leafminer larvae. Cage experiments will be set up in the field with these predator and pest species combinations to determine predation rates. Cages will be infested with a known number of predator species along with individuals of the pest species to be tested. Counts of living prey and predators will be made daily for the first 5 days, henceforth every other day until all prey are killed and consumed. Each combination of predator species and pest species will be replicated 5 times. Unknown predator species will be sent to a specialist for identification. Predator populations will be sampled in the non-pesticide field described below in part to determine their abundance and diversity in this situation.

Determination of economic injury levels and action threshold levels for leaf miners, thrips and aphids. [Adipala; S. Kyamanywa - Makerere University; G. Epieru, R. Hammond; Undergraduate student - Makerere University]

Different chemical spray regimes will be used to vary population density and damage caused by leaf miners, thrips and aphids. Dimethoate will be the insecticide used in this trial, it will be applied at a rate of 1.25litre/hectare. Dithane M45 will be used to control Cercospora leaf spot. The treatments will include insecticides applied: once a week, twice a week, once every two weeks, and a control (no pesticides used). The trial will be a completely randomized block design and replicated four times. The study will be conducted at MUARIK and TVC at Kumi. Rosette incidence, leaf miner damage, aphid and thrips infestation will be assessed. At maturity, grain yields will be determined. Data collected will be subjected to Analysis of Variance (ANOVA). Gross Margin Rate of Return analysis will be used to determine the cost-benefit ratio of each spray schedule. Economic Injury levels of the two pests will then be computed and an insecticide spray schedule designed.

**f.** **Justification:** Groundnut rosette and cercospora leaf spots are major constraints to groundnut production, with farmers frequently recording total crop failures. Possible control measures include manipulation of plant density, early planting, use of resistant varieties and chemical sprays. As with other crops, disease and pest infestations on groundnut occur simultaneously. A better approach is to integrate control technologies in an IPM package in order to offer holistic crop protection for groundnuts. Currently recommended IPM packages have tended to be disease specific (usually directed at rosette or early leaf spot) and pest specific (directed at aphids), yet these pests and diseases often occur together.

Previous IPM CRSP activities have developed possible IPM packages for the control of these two diseases. However, these IPM packages need to be validated and disseminated to groundnut farmers. During the IPM CRSP studies other biotic constraints on groundout were recorded but their effect on yield has not been substantiated and at the same time no control measures have been designed for them. In this study, EILs and AT's for the commonly encountered constraints (leaf miners and thrips) will be determined and control measures designed. Biological control is usually recommended as the first line of defense in IPM. To implement bio-control we need to know the natural enemies in the system. Sub-activity (2) represents our attempt to utilize and maximize bio-control in the IPM system we are designing for groundnut in Uganda/ East Africa.

**g**. **Project Output**: Validated IPM packages for groundnut rosette and Cercospora leaf spots available to groundnut farmers. Other important pests and diseases of groundnut documented and control strategies identified. A list of predators and parasitoids of major insect pests that are most important in controlling of groundnut pests compiled and one Postgraduate/undergraduate student will be trained.

**h.** **Project Impact**: (1) Reduced usage of pesticides; (2) Development of an IPM package for groundnuts; (3) Reduced production costs and increased yield of groundnut in Uganda.

**i.** **Progress to Date**:

- Effects of time of planting, host resistance, plant spacing and pesticide application on groundnut rosette virus and Cercospora leaf spot have been studied.
- Fifty-seven groundnut genotypes from ICRSAT have been screened for resistance to groundnut rosette virus and Cercospora leaf spot, in two growing seasons.
- Efficacy of different pesticide in controlling major pests and disease of groundnuts have been studied during two previous cropping seasons.
- A survey of natural beneficial insect has been conducted during one growing season.
- One M.Sc student has been trained, graduated, and is now working for CIAT/Uganda.
- Four undergraduate students have been supported in their special project research (Mr. Dan Kabuye, G. Ishiagi, G. Kawube & Frank …………)

**j.** **Started:** September 2000

**k.** **Project Completion:** September 2003

**l.** **Projected Person-Months of Scientist Time per Year:** 3 months

**m.** **Budget for 2001/2002:** Makerere University – $ 22,530; Virginia Tech – $2,809; OSU – $3,906

**I.2. Important Cereal Crops associated with Farming Systems in Eastern Uganda.** This section focuses on continuing research activities to address major insect, disease and weed constraints on two important cereal staples, sorghum and maize.

**I.2.1. Integrated Pest and Disease Management Strategies for Maize In Uganda Year 10 Proposal**

**a.** **Scientists**: G. Bigirwa and Twaha Kalule, Sekamatte, B. NARO/NAARI; R.C. Pratt, P.E. Lipps and Ron Hammond, OARDC - OSU; S. Kyamanywa, E. Adipala, R. Edema - Makerere University; Graduate Students: R.G. Asea and S. Gordon, OARDC - OSU.

**Collaborators:** K. Pixley (CIMMYT); A. Mwang'ombe (University of Nairobi); J.B.J. van Rensburg (Grain Crops Institute, R.S.A.), Charles Omwega, ICIPE).

**b.** **Status:** Continuing Activities

**c.** **Overall Objectives:** (1) Enhance sustainability of maize production in mid- and high-altitude agro-ecosystems by improvement of host resistance to the leading foliar pathogens {Maize streak virus (MSV); *Exserohilum turcicum*, causal agent of Northern Leaf Blight (NLB); and *Cercospora zeae-maydis*, causal agent of gray leaf spot (GLS) disease and insect pests; stemborers (*Chilo partellus)* and termites. (2) Improve the ability to select host resistance to GLS by development of a laboratory based inoculation protocol (3) Enhance activity of biological agents to control termites and stemborers.

The specific objectives are: (1) Quantitative trait locus (QTL) mapping utilizing molecular-markers to enable marker-assisted selection (MAS) of quantitative resistance loci conferring resistance to MSV, NLB and GLS; (2) Development and testing of an inoculation technique involving *in vitro* cultured detached-leaves similar to that used for evaluating resistance to other cereal diseases (e.g. *Stagonospora* blotch of wheat) to determine if it will work for GLS screening; (3) Continue impact assessment study of *C. flavipes*; (4) Integrate application of ant baits and intercropping maize with *Desmodium*, soybean and cowpeas for termite and stemborer control.

**d.** **Hypotheses:** (1) Identification of significant QTLs for GLS resistance can be verified and shown to be heritable; (2) the QTlLs may result from the presence of major resistance genes so resistance gene analogs (RGAs) may be located in or near marker intervals that were significant for GLS; (3) Inconsistency of the earlier greenhouse inoculation protocol for GLS was probably due to the type of resistance being evaluated (partial resistance), to the long latent period required by the disease (14 to 18 days) and rapid growth of plants during early growth stages. We hypothesize that use of the *in vitro* assay will enable natural disease progress to occur; (4) The establishment and spread of an introduced parasitoid (*C. flavipes*) will reduce the infestation levels of the exotic stemborer (*C. partellus*) 5) Applying ant baits (fish/molasses) in maize-legume intercrops will lead to significantly lower termite and stemborer infestation levels than when either of them if used alone.

**e. Description of Research Activity:**

Approaches to increase availability of germplasm with durable resistance to multiple disease (gray leaf spot, northern leaf blight and maize streak virus). Selective genotyping was initially performed on the resistant and susceptible tails of the population derived from the cross Pa405 (susceptible) and the South African line VO613Y (resistant). We previously identified two quantitative trait loci (QTLs) for resistance, one on 1L (from Pa405) and another on 2L (from VO613Y). We will add additional SSR markers (approx. 30) and additional progeny lines (50-60) to ensure total genome coverage of 100+ markers. We will attempt to confirm the marker on chromosome 2L, and search for other resistance QTLs using the increased coverage and expanded population size. This is important to ensure the successful initiation of the expanded work on multiple disease resistance that will be accomplished through transfer of GLS QTLs identified in South African inbred VO613Y into CML202 (as described in biotech proposal).

Because the previous research suggested that resistance may be under major gene control, we will also include primers for resistance gene analogs (RGAs; a gift from Kansas State University) in our attempt to identify more markers in the expanded population. This will test the hypothesis that RGAs are located in or near marker intervals that were significant for resistance based on PLAA values. RFLP markers that may be significantly linked to resistance loci will be converted to cleaved amplified polymorphic sequence (CAPs) so that can be utilized as polymerase chain reaction based (PCR based) markers without the need for hybridization which requires radionucleotides.

In addition to PLAA data, lesion lengths and numbers will be assessed for selected resistant and susceptible lines and heritability estimates will be calculated by parent-offspring regression. Heritability estimates for the components of resistance mentioned above.

In vitro bioassay for screening maize germplasm for GLS resistance. Techniques have been developed to test for quantitative resistance in other host-pathogen systems that have long latent periods. We propose to evaluate *in vitro* detached-leaf techniques (Benediza et al., 1981; Kisha et al, 2001) used for evaluating resistance to other diseases e.g. *Stagonospora* blotch of wheat, in order to screen for resistance in maize to *C. zeae-maydis*. The techniques for the wheat protocol (Bendedikz et al, 1981; Kisha et al, 2001) will be modified and adapted to maize at OSU. Additionally, a potato leaf blight protocol (Toxopeus, 1954) will be modified and adapted by our cooperator at the University of Nairobi. Funding for the work in Nairobi has been solicited from the Rockefeller Foundation. Our objective will be to share results and cooperate on finding a practical procedure.

Briefly, leaves will be detached from green house grown plants at two different stages of development (V4 and V6-V7). They will then be surface sterilized and small sections will be excised and placed on wet blotting paper in petri dishes. Combinations of plant growth regulators e.g. anti-senescence compounds (cytokinins such as benzyladenine) and growth retardants (such as Flurprimidol, trade name Cutless) will be added to the medium at several different doses. The objective will be to find a treatment that slows the growth and or senescence of the plant material so that it can be preserved long enough for the pathogen to invade successfully. Progress of the fungal pathogen and the host tissue will be monitored under a dissecting microscope. Local isolates will be tested initially for their pathogenicity. Data obtained will be used to develop response curves. When a suitable procedure has been identified in a highly susceptible genotype, additional tests will be performed with susceptible, intermediate, and resistant genotypes to examine whether or not the detached-leaf bioassay can separate them. The leaf bioassay will then be correlated with field evaluations of the same genotypes in blind tests to be conducted in Ohio and Uganda.

Stemborer management.

Impact Assessment**.** Stemborer larvae will be collected on a monthly schedule during the long and short rainy seasons from release sites located in Iganga, Kumi, and Masindi districts to determine parasitoid establishment and evaluate impact of biological stemborers. Field sites included in the study will primarily include on-farm management plots linked to IPM/CRSP. Kumi district represent the mid-altitude semi-arid zones with a predominantly cereal (maize-sorghum-millet) cropping system surrounded by land rich in wild hosts. Masindi and Iganga are in the mid-altitude humid agro-ecologies in a predominatly maize-banana-coffee system. Data will be collected on: (1) Stemborer density/plant (2) percentage parasitism (3) stemborer species composition (4) parasitoid species composition (5) percentage parasitoid emergence (6) stemborer damage; stalk tunnel length, leaf damage, number of nodes damaged. The student will carry out studies on: (1) estimating mean borer densities in a small area (cohorts) (2) time specific mortality.

Study on spread**.** The efficiency of a released natural enemy depends on the searching capacity and rate of dispersal (spread). These to a large extent indicate whether the natural enemy would be fully established or not. The first stage in impact assessment therefore involves the determination of the spread and establishment of the natural enemy. Sampling outside release sites in Kumi, Iganga and Masindi districts will be carried out to determine the extent to which the parasitoid has colonized new areas from point of release. Starting from the release site, systematic samples will be taken in different directions (axes) 2-3 times a season. To obtain a population estimate of *C. partellus* and the natural enemies, the field will be randomly sampled. Whenever *C. flavipes* is observed in the field, sampling will continue on this axis for another few kilometers in order to establish the spread. Data will be taken on the stemborer and natural enemy complex.

Termite management. Previous work on termites using fish based bait showed an increase of 84% ant activity and 54% termite reduction. In year 10 it is being proposed to demonstrate the technology on farmers' fields in two districts, Masindi and Iganga. A participatory approach will be used where farmers' groups will discuss the technology and identify farmers who will participate in the demonstration. Fifteen demonstrations will be established in each district. A modified farmer field school approach will be used, in which farmers will be involved in activities like; planting, mixing of the fish bait, its application and monitoring the damage. The treatments in the demonstration will include; plots with and without fish bait and will measure 15 x 20 meters separated by 2m alley. Farmers will serve as replications. The fish bait will be applied at a rate of 500 grams per plot at 4 and 9 weeks after emergence. Date will be taken termite damage, ant activity and yield. The incidence of predatory ants will be assessed by inspecting the forty plants sampled for termite damage for presence of ant nests within a 25 cm radius around the plant stem bases. An ant- nesting index expressed as the number of maize plants out of 40 with ants nests will be calculated.

**f. Justification:**

(1) Gray leaf spot (*Cercospora zeae-maydis*), maize streak virus, and northern leaf blight (*Exserohilum turcicum*) are the three major maize diseases in Uganda. Considerable efforts are being made by the national research programs (NARO and Makerere) in collaboration with scientists from other institutions like OARDC-USA and CIMMYT to address these diseases. Several control and management options have been tried but host resistance is the most cost effective for the majority of farmers in the country. Conventional breeding takes long and is not as precise as new biotech tools that are readily available in advanced laboratories of OARDC-USA. These new tools will be employed to help in the selection and identification of sources of resistance for use in improving the elite materials in Uganda. Stem-borer parasitoids appear to be having an impact on stem-borer populations. Verification of this would support the initial efforts to examine the feasibility of releasing an additional parasitoid species

(2) The introduction and establishment of *C. flavipes* represents a case of biological control that should have a sustainable impact on the reduction of stemborer injury. Previous studies indicate that *C. flavipes* has had good establishment in Kumi and Iganga districts but very poor establishment in Masindi (<10%). These studies also show a strong correlation between grasses (cereals + wild hosts) and parasitism especially in Kumi. What are not clear are the observed differences in establishment of the parasitoid in the release sites. Thus, it is important to understand the factors that account for the differences in establishment and spread of *C. flavipes* across locations and its effect on the target pest, the stemborer complex and the associated parasitoid complex. Such knowledge would be used in strengthening and sustaining its impact on stemborer populations.

(3) Termite damage is another limiting factor in maize production. Recent studies in Uganda have indicated that both intercropping and application of fish bones and molasses reduce termite attack on maize by enhancing the activity of indigenous predatory ants (Sekamatte, 2001). Species of the genera *Myrmicaria* and *Lepisiota* were the dominant ant predators recorded. These results need to evaluated and disseminated to farmers.

(4) We are concerned with publishing the results of the greenhouse inoculation protocol because it has been difficult to repeat. It is especially difficult to quantify the amount of disease on the immature plants. We were hoping the technique would work better, but we did not seem to get the level of disease needed to easily separate germplasm with known reactions in the field. Inconsistency may be due to the type of resistance being

evaluated (partial resistance), to the long latent period required by the disease (14 to 18 days) and rapid growth of plants during early growth stages. Regardless, it is not an easy task to perform and it is important that pathologists will be satisfied with the technique.

We feel we may need to resort to a more precise type of bioassay. Techniques have been developed to test for quantitative resistance in other host-pathogen system that have long latent periods. We feel we should try some of these techniques to see if they work for *C. zeae-maydis*. Basically the technique involves an in vitro detached-leaf assay used for evaluating resistance to other cereal diseases (Stagonospora blotch of wheat). This would eliminate the problem with maintaining proper environmental conditions in the greenhouse and the rapid growth of young plants. The most difficult part will be keeping leaf tissues alive in culture for 14 or more days.

g. **Relationship to other activities:** (1) The proposed work will complement the on-going studies on identifying farming components responsible for high GLS incidence and development, identification of sources of resistance to 3 main foliar diseases, and effect of stover on GLS development. It will also make a follow-up to IPM CRSP funded activities so that the farmers come to know the diseases affecting maize production and start to take steps to contain them. (2) This study follows previous studies on IPM/CRSP studies on stemborer/parasitoid interactions and release of the braconid parasitoid, *C. flavipes*. The study will focus on field sites carrying out IPM/CRSP activities and other farmers in the vicinity. (3) The effects of fish baits, broadcast or buried with a few dry stalks of maize, in a maize crop, termite activity and damage have been studied. (4) The proposed work will compliment other management options being tried out e.g. crop rotation with non-cereals, increased soil fertility and host resistance.

h. **Progress to date:**

(1) Graduate student (S. Gordon) completed the research and analysis on the initial QTL mapping effort using selective genotyping. Two resistance QTLs are associated with resistance and they appear to be different than those reported in the US. (2) A manuscript describing the above results has been submitted to the Crop Science journal. (3) The work described above using the expanded population and additional markers has been initiated. (4) Most resistant segregating lines have been planted in the greenhouse for crossing with CIMMYT lines CML 202 and CML 390. (5) Graduate student (Asea Godfrey has successfully completed first quarter of study at OSU). (6) The manuscript on epidemiology of GLS in tropical environment has been published in the Annals of Applied Biology (G. Asea, , G. Bigirwa, E. Adipala, S.A.P. Owera, R.C. Pratt and P.E. Lipps. 2002. Effect of *Cercospora zeae-maydis* infested maize residue on progress and spread of grey leaf spot of maize in Central Uganda. Annals of Applied Biology 140:177-185. (7) A paper was entitled: The effect of farming systems on the development of GLS epidemics in two districts of contrasting incidence, was presented during the Seventh East and Southern Africa Maize Regional Conference held in Nairobi, February 2002: The authors are Bigirwa, G., Pratt, R.C., Adipala, E. and Lipps, P.E.

(1) Evidence of parasitoid establishment has been documented in some areas with parasitism rates of up to 30%. (2) Recovery of the parasitoid in non-release areas

demonstrates the ability of the parasitoid to colonise new areas. (3) The high emergence rate of adult parasitoids indicates that there are probably no negative cultivar-mediated effects on parasitoid survival and development. (4) 2 M. Sc. level Makerere graduate students have began their studies on the project and are working closely with NARO scientists. However, percent parasitism was highly variable over locations with parasitism levels of *C. flavipes* less than 10% in some locations. The challenge is to try and explain the underlying factors influencing the observed differences in establishment of the parasitoid across locations.

One season's data has been collected and analysed. Results of analysis and field observation on treatment impact on stemborers indicate high potential of the two techniques to control both termites and stemborers.

**i.** **Projected Outputs:** (1) resistance factors and their association with components of resistance identified; (2) SSR molecular markers for MAS selection identified. (3) An alternative strategy for termite and stemborer management developed. (4) A rapid screening tool to allow inoculation of plants with GLS at any time thus improving the efficiency of host resistance selection for breeders (5) Increased, sustainable maize yields.

**j.** **Projected Impacts:** (1) reduction in maize losses and increased production; (2) a shortened process for identifying sources of resistance, selection and testing; (3) enhanced maize resistance to many diseases; (4) sources of resistance for utilization in Uganda and USA not only identified – but utilized.

**k.** **Projected Start Date:** September 2002

**l.** **Project Completion:** September 2003

**l.** **Project Person-Month of scientist time per year:** 3 months

**n**. **Budget:** NARO – $13,805; OSU – $21,672

### I.2.2. Development of options for *Striga* management for small holder sorghum farmers

**a.** **Scientists:** J.R.Olupot - MAAIF; B. Sekamatte - SAARI/NARO; J. Oryokot - NAADS; Herman Warren and Brhane Gebrekidan - Virginia Tech

**Collaborating Institutions :** ICIPE and NAARI.

**b.** **Status:** Continuing activity with some modification in methodology.

**c.** **Objectives:** (1) To evaluate the effect of intercropping sorghum and silver leaf desmodium (*Desmodium uncinutum*) in the management of *Striga*. (2) To identify 2,4-D and 2,4-DB herbicides tolerant sorghum genotypes and evaluate the efficacy of herbicide seed coating in *Striga* management. (3) To develop an effective and rational crop rotation system for *Striga* management in eastern Uganda. (4) To determine the effect of integrating intercropping, seed coating and fertilizer use for the management of *Striga*

**d.** **Hypothesis:** (1) Inter-cropping sorghum and silver leaf desmodium affects *Striga* infestation in sorghum. (2) Seed coating sorghum seeds with 2,4-D and 2,4-DB herbicides reduces striga infestation in sorghum. (3) There are differences in *Striga* infestation under continuous sorghum cropping and the proposed crop rotation system. (4) There are differences in sorghum yields between the integrated management strategy and single practice management options.

**e.** **Description of research activity:**

Effect of intercropping sorghum with Desmodium on Striga infestation. A field trial will be carried out in farmers' fields at five sites in Kumi district to evaluate the efficacy of intercropping Seredo with silver leaf desmodium in *Striga* management. *Desmodium* will be compared with other known trap crops i.e. Cowpea, Bambara nuts and *Celosia argentia*. *Desmodium* will be left in the field for two seasons and plots will be permanently marked in order to realise its full effect. This is because the rate of growth of *Desmodium* has been observed to be slow. The planting arrangements will include: 1:1, 2:1, 2:2 and 1:2. Application of a recommended fertilizer rate will be included as a control. Data to be collected will include *Striga* emergence, *Striga* soil seed bank, crop growth parameters, sorghum yield, total *Desmodium* biomass and stalk borer damage. Statistical analysis will be carried out using Genstat statistical package.

Screening sorghum germplasm for tolerance to 2,4-D and 2,4-DB. Sorghum germplasm that have shown tolerance to 2,4-D and 2,4-DB seed coating will be taken for field evaluation. This will be an on-farm trial conducted in Kumi district at five hot spot *Striga* sites, to evaluate the efficacy of coating sorghum seed with 2,4-D and 2,4-DB on *Striga* control.A lower herbicide concentration of 0.05% a.i for each of the herbicides will be used. Data to be collected will include; *Striga* seed germination and emergence, crop growth parameters and crop yield. Statistical analysis will be carried out using Genstat statistical package.

Effect of cotton/sorghum/cowpea rotation system on *Striga* infestation. This is an ongoing study which was started on farmers field initially identified as striga hot spot in Kumi District. Two cropping regimes were imposed; one to receive a cotton/sorghum/cowpea rotation treatment and the other continuously cropped with sorghum. This is replicated five times. The cropping scheme is as follows: (1) Cotton/sorghum/cowpea: 1$^{st}$ rains 1997 (cotton), 1$^{st}$ rains 1998 (sorghum), 2$^{nd}$ rains 1998 (cowpea), 1$^{st}$ rains 1999 (cotton), 1$^{st}$ rains 2000 (sorghum), 2$^{nd}$ rains 2000 (cowpea), 1$^{st}$ rains 2001 (sorghum), 2$^{nd}$ rains 2001 (cotton), 1$^{st}$ 2002 (sorghum). (2) Continuous sorghum cropping: under sorghum all seasons up to 1$^{st}$ rains 2002. Recommended fertilizer rates, varieties and cultural practices will be used in all plots. The recommended fertilizer rate is to provide 80kgNha$^{-1}$. The recently recommended sorghum variety for the area, Seredo will be planted. The recommended varieties for cotton and cowpea for the Kumi area will also be planted. Appropriate cultural practices for the management of these crops will be followed, including planting dates and plant densities. The data to be collected will include *Striga* plant count after emergence, *Striga* seed bank in the soil, both at the start of the trial and at the end of each season in both the rotation and continuous sorghum plots. In each plot, soil sampling will be carried out along the plot length. A five-centimeter diameter soil auger will be used to obtain soil cores to the depth of the plough layer (approx. 10cm). A total of twenty soil cores will be obtained from each field and composted to give a single sample from which *Striga* seed bank will be determined. Soil and socio-economic analysis will be performed and the impact on *Striga* interpreted on that basis.

<u>Integration of intercropping, seed coating and fertilizer use in management of *Striga*.</u> An on-farm study will be conducted at five *Striga* hot-spots in Bukedea; two sites with UNFA Kachede farmers and three sites with BUWOSA farmers. The trial will consist of the following options; (1) the integrated *Striga* management practice identified from an earlier study; (2) intercropping seredo sorghum with silver leaf desmodium and (3) seed coating with herbicide and cultural practice. Data to be collected will include emerged *Striga* plants, *Striga* soil seed bank, crop growth parameters, crop yield and person-hours (days) for weed control. In each plot, soil sampling will be carried as indicated above in section 1-3. Available soil nitrogen will also be determined. Rainfall data will be collected using portable rain gauges for interpretation of the data. Statistical analysis will be carried out using SigmaStat statistical package. A paired t-test will be used to compare farmer practice and the integrated *Striga* management strategy.

**f.** **Justification:** The integrated management strategy for *Striga* developed is suitable for farmers when the yields are good and can compensate for low price of sorghum and the cost of fertilizer. Under either poor yields due to drought or low sorghum price, the cost of fertilizer may not be recouped. Under these conditions, viable options for the management of *Striga* that provide farmers with choice under different sorghum production environments are needed. The West African site in Mali has been evaluating seed coating of sorghum seed with 2,4-D and 2,4-DB as a possible component for management of Striga. Both 2,4-D and 2,4-DB have been tried on a limited number of sorghum genotypes under Ugandan conditions. Preliminary results of one season indicate promise in suppressing *Striga* emergence but had negative impact on sorghum performance at 0.1% concentration of the herbicides. The new approach is to lower the herbicide concentration to 0.05% and screen more sorghum germplasm available in the country. Elsewhere (ICIPE), *Desmodium* has been shown to reduce *Striga* infestation when inter-cropped with maize as well as reducing stalk borer infestation. This effect of Desmodium needs to be evaluated on sorghum in Uganda. Preliminary results have indicated that Desmodium has potential to reduce *Striga* infestation and improve on sorghum yield. These findings need to be re-validated in order to get more accurate and reliable data. In addition, the need to conduct a socio-economic analysis of these findings requires four (4) season's data.

**g.** **Relationship to other CRSP activities:** This work is related to other CRSP activities that have been conducted under controlled conditions at Virginia Tech to develop novel approaches to *Striga* management. It is also related to the *Striga* management studies being carried out in Mali, West Africa. All these studies are aimed at developing management options for *Striga* management that are suitable for small-scale farmers.

h. **Projected output:** Novel management options for *Striga* management in Ugandan conditions.

i. **Projected impacts:** (1) Reduced incidence of *Striga*; (2) High sorghum yield; (3) Depleted *Striga* seed bank; (4) Higher income for small-scale sorghum farmers.

j. **Progress to date:** The earlier part of this work involving development of an integrated management strategy for *Striga* has been completed and has been written as part of the student's Msc. Work and presented in International Weed Science Conference. The crop rotation study will be entering the seventh season on the site. Preliminary results on intercropping and seed coating have shown promise for *Striga* management in Uganda.

k. **Start-date:** 1998

l. **Projected completion:** September 2003

m. **Projected person-Months of Scientist Time per year:** 3 person months of scientists time per year. A full time student involved with the project is now at the final stages of completion.

n. **Budget:** Makerere/Uganda – $ 5,458; Virginia Tech – $6,002

**II.1. Development of IPM strategies for High Value Horticultural Crops.** Activities will continue in Year 10 on developing IPM strategies for tomato. Activities on potato have been concluded and USA and Ugandan collaborators have either retired or been reassigned.

**II.1.1 Development of IPM Technologies for Tomato Production in Central Uganda**

a. **Scientists Names and Institutional Affiliations**: Akemo M.C., Hakiza J.J. - KARI; Kyamanywa S., Adipala Ekwamu, M. Magambo, A. Kaaya - Makerere University; M. Erbaugh, R. Hammond and P. Grewal - Ohio State University; A. Alumai Graduate Research Assistant funded by OSU.

b. **Status**: Continuing activity.

c. **Overall Objectives**: To reduce the use of pesticides on tomatoes. The specific objectives are: (1) To develop alternative interventions for controlling priority diseases and pests of tomatoes; (2) To identify bacterial wilt resistant indigenous Solanaceae rootstocks for tomato grafting; (3) To establish the levels of dithiocarbamates in tomatoes and their effects on shelf-life (4) To develop biological control alternatives involving entomopathogenic nematodes to manage thrips and African bollworm.

**d.** **Hypothesis**: (1a) Improved tomato varieties and cultural practices will reduce incidence and severity of bacterial wilt, early and late blight, and insect pests (1b) The frequency of pesticide application can be reduced without yield loss. (2) Use of grafting and rootstocks resistant to soil-borne diseases will reduce disease incidence. (3) There are high levels of pesticides residues on tomatoes sold in Ugandan markets. (4) Entomopathogenic nematodes are effective alternatives to chemical pesticides in the management of thrips and African bollworm on tomatoes in Uganda.

**e.** **Description of Research Activity (approach):**

Evaluation of selected tomato lines and management practices on incidence of *Phytophthora infestans, Ralstonia solanacearum,* and insect pests on tomatoes. (Akemo M.C, J.J. Hakiza, H. Warren, M. Olanya). After the 2002a season on station, the 3 best performing lines and the 3 management practices which combine the best disease and insect pest control with economic yields will be taken and tested on-farm for 2 seasons. This will be done with 2 farmers' groups at 2 different tomato-producing areas in Wakiso District. A check trial will be run on-station at KARI at the same time. The design will be a split block, with management practices as the main plots, replicated 3 times. The tomato treatments will be replicated within the management practices. The locally grown varieties will be used as controls, making 4 tomato treatments in total. Data will be collected on diseases (*Phytophthora infestans, Ralstonia solanacearum*) and insect pest (*Thrips tabaci, Myzus persicae, Helicovepa armigera, Bemisia tabaci*) incidence and severity at biweekly intervals. The trials will also serve as demonstration sites from which the farmers will select the best option.

Field performance of tomatoes grafted on selected *Solanum* sp rootstock. (Magambo M.J.S., Kasenge V., Kyamanywa S.**)**. Rootstocks of *Solanum indicum* subsp. Distichum, *S. macrocarpon*, and *S. camphylocanthum* will be grown in the field in a randomized complete block design with 4 replications. Thereafter tomato scions of local popular varieties will be grafted on to the rootstocks at the right stage. Data will be collected on general growth characteristics of the grafted plants, disease and yield. , and economic implications will be assessed. The data will be statistically analyzed. The experiment will be carried out on selected farmers' plots in Wakiso district.

Determination of dithiocarbamate fungicide residues in tomato fruits. (Kaaya Archileo). Tomato samples of 1kg each will be purchased from Nakasero and St. Balikudembe markets. Five samples will be obtained from each market and their residues determined. Another batch of 10 samples of 20 fruits each will be purchased from farmers and their shelf-life attributes (color, firmness, pH, TSS, acidity, and microbial infection) evaluated using data obtained in year 9 on the dithiocarbamate levels applied by farmers. All studies shall be done in the Department of Food Science and Technology, Makerere University.

Evaluation of three entomopathogenic nematode strains for the control of thrips and African bollworm on tomatoes (Alfred Alumai**)**. Two trials will be conducted at the Kwanda Agricultural Research Institute (KARI) on tomatoes. One trial will evaluate the potential of nematodes to control thrips and the other will be for the African bollworm. There will be 5 treatments in each trial involving three nematode species, a standard insecticide treatment, and an untreated control. Plot size will be 2 x 2 m and a complete randomized design with 5 replications will be used. The treatments will be applied as curatives with sprinkling cans late in the evening. The nematode species will be *Heterorhabditis bacteriophora* (Ohio strain), *H. zealandica* and *Steinernema carpocapsae*. Data on insect mortality shall be recorded two weeks after application. Plant damage and yield will be assessed before harvest. These two experiments will be repeated during two growing seasons.

Capacity building. A student is being trained in entomology at MSc level at MUK.

**f.** **Justification:** Tomato blights and Bacterial wilt have been ranked both by NARO and farmers as priority diseases on tomatoes in Uganda. There is also extensive damaged caused by insect pests such as thrips (*Thrips tabaci*), African bollworm (*Helicoverpa armygera*), and. vectors of tomato viruses. To control these problem farmers rely on extensive use of pesticides. Farmers, however, do not use pesticides correctly, resulting in undesirable residues on the harvested tomato fruits. The levels of these residues are not known. There is need to reduce pesticide use studying the effect of different cultural methods on Late blight will help reduce pesticide applications against this disease and reduce crop loses. Similarly resistant varieties and grafting are 2 methods that can be employed to avoid crop loss from the soil-borne bacterial wilt.

**g.** **Relationship to other CRSP activities at the site:** The proposed research builds upon on-station studies at KARI and MUARIK that have been examining alternative methods of controlling tomato diseases and insect pests. It also follows upon studies initiated on dithiocarbamate residues on tomatoes.

**h.** **Progress to date:** 1½ year's testing the effect of 7 management practices and 13 bacterial wilt resistant lines introduced from AVRDC Taiwan have been carried out. Six *Solanum* rootstock species were tested for compatibility with tomato scions and resistance to *Ralstonia solanacearum*. Three management practices are reducing severity of late blight infection. Out of the 13 introductions only 3 have had some plants wilting. All the 6 rootstocks were compatible with tomato scions. However, only *Solanum macrocarpon, S. indicum* subsp *distichum,* and *S. camphylocanthum* were compatible and resistant to Bacterial wilt. On pesticide residues samples were obtained from farmers and the markets at Gayaza, Kasangati, and Kalerwe. Information on levels and frequency of Dithane M45 application was obtained.

**i.** **Projected outputs**: (1) Bacterial wilt resistant/tolerant tomato cultivars identified. (2) Alternative disease and insect pest management practices developed. (3) Information on the levels of dithiocarbamate residues in tomatoes and the role of the different levels of DM45 in prolonging the shelf life of tomatoes shall be established. (4) Student trained to MSc level. (5) Publications.

**j.** **Projected impact:** (1) Losses due to tomato diseases and pests reduced. (2) Farmer's incomes increased. (3) Reduction in pesticide use. (4) Awareness by consumers on the safety hazards of tomatoes in Uganda and the role of DM45 as a post-harvest fungicide. (5) Capacity to handle horticultural entomology problems increased.

**k.** **Project start**: September 2002

**l.** **Project end**: September 2003

**m.** **Projected Person-months of Scientisits' Time per year**: 12 months

**n.** **Budget:** Makerere/NARO – $15,147; OSU – $7,560.

## III. Post-harvest

### III.1.1 Moulds and Mycotoxins in Maize and Groundnuts in Uganda

**a.** **Scientists**: A. N. Kaaya, E. Adipala, S. Kyamanywa – Makerere University; H. Warren – Virginia Tech; A. Agona – KARI and G. Bigirwa – NAARI, G. Sseruwu-Makerere University

**Collaborators:** Rockefeller Foundation

**b.** **Status**: Continuing activity

**c.** **Overall objective**: To identify on-farm practices/factors which influence mould incidence and mycotoxin contamination of maize and groundnuts. **The specific Objectives for Year 10**: (1) To compile harvesting, drying, shelling and storage regimes of maize and groundnuts at farm and market levels as they relate to moulds and mycotoxin contamination of these commodities; (2) To study changes in moisture content, insect damage, germination potential, mould and mycotoxin contamination of solarised and non-solarised maize kernels; (3) To validate recommended improved drying methods on moulds and mycotoxins in maize; (4) To establish temperature and exposure periods that eliminate moulds and prevent subsequent mycotoxin production in grains; (5) To train a graduate student at PhD level.

**d.** **Hypotheses**: (1) Prolonged exposure of maize kernels to solarisation temperatures significantly affect their moisture content, insect damage, germination potential, and subsequently mould and mycotoxin contamination. (2) Drying maize in biomass dryers significantly reduce mould infection. (3) Oven method can be used to establish temperature and exposure times to eliminate moulds from grains.

**e.** **Research Activity:** (1) The Ph.D. student has already registered at Makerere University. The student will carry out coursework at Virginia Tech beginning August 2002 for one year and thereafter return to Uganda to continue with research and write a dissertation. IPM CRSP shall maintain the student at Virginia Tech and finance research in Uganda.

Makerere University shall pay for tuition while the student is in Uganda. Data on harvesting, drying, shelling and storage regimes of maize and groundnuts at farm and market levels shall be compiled, analyzed and paper/report written while at Virginia. These data are available from the previous studies. Thirty maize samples dried in the field shall be collected from 15 farmers from Mayuge district 2 samples per farmer. The samples shall be subjected to solarisation for 3, 4, 5 and 6 hours and stored in PE bags. Moisture content, insect damage, germination potential, moulds and mycotixins shall be analyzed before and after solarisation. The solarised samples shall be sent to USA so that they can be analysed by the student while there. The biomass dryer shall be used to establish the effects of improved drying methods on destroying moulds. The oven methods shall be used to dry maize samples in order to establish the optimum temperature and period for the elimination of moulds. (2) The RF will fund all research activities of the MSc. student who will look at fungal microflora responsible for ear rots in maize in highlands and mid-altitudes of Uganda; maize variety evaluation for ear rots resistance, and identifying suitable inoculation method for ear rots.

**f.** **Justification:** During Year 9 it was observed that information on harvesting, drying, shelling and storage regimes is needed by farmers, traders and exporters to control mycotoxin contamination in maize and groundnuts. Solarisation for 3 hours was found to be effective in reducing moisture content and insect infestation but not moulds and germination potential. There is the need to increase the exposure time and also study the virulence of the moulds and their ability to produce mycotoxins during storage. Biomass drying is a method already recommended for drying maize and has been adopted by some farmers in Kapchorwa. This method needs to be validated in terms of mould and mycotoxin control. Oven drying gives consistent and exact temperatures that can easily be obtained to destroy moulds. This information is very important for recommending drying regimes of grains especially those intended for export. There are some funds budgeted for the student to go to Virginia Tech for course work during Year 9. Ear rots are becoming of economic importance and this has led to rejection of grain desired for export. Some commercial varieties are succumbing to the disease hence the need to identify sources of resistance

**g.** **Relationship to other CRSP activities at the site:** The proposed study is related to on-going work on moulds and mycotoxin incidence in maize and groundnut and also to post harvest studies related to storage and insect infestation control.

**h.** **Progress to-date:** PhD student has already registered at Makerere University and is in the process of going for coursework at Virginia Tech. Moisture content, insect damage, germination potential and moulds have been determined in maize in relation to harvesting, drying, shelling and storage practices in Mayuge district. Solarisation of maize kernels for three hours was carried out and it was found to have no significant effects on moulds and germination potential, but significantly reduced moisture content and killed all insect pests. Maize stored by traders for 5-6 months had the highest insect damage and mould incidence. Except kernels obtained from the field, the rest had poor germination potential and this was attributed to poor methods of drying, beating during shelling and insect damage.

i. **Projected output:** Relevant technologies required to control and monitor moulds and mycotoxin contamination during handling and storage of grains shall be established.

j. **Projected Impacts:** (1). Control of moulds and mycotoxin contamination of maize and groundnuts in Uganda (2) Increased export potential of maize and groundnuts (3) Improved consumer safety of grains.

k. **Projected start:** October 1, 2002

l. **Projected completion:** September 30, 2003

m. **Projected Person-Months of scientists time per year:** 3 months

n. **Budget:** Makerere – $8,806; Virginia Tech – $14,875

### III.2.1. Effect of Splitting on Biology of *C. maculatus,* Quality Attributes and Marketability of Cowpea Seeds

a. **Scientists:** J. A. Agona, S. Kyamanywa, A. Kaaya, H. Warren, J. Bonabana, V. Kasenge, W. Ekere, M. Erbaugh and D. Taylor

b. **Status:** Continuing

c. **Overall Objective**: To promote processing, storage, utilization and marketability of split cowpeas. **Specific objectives**: (1) To study the biology and population dynamics of *C. maculatus* on split cowpea; (2) To determine the effect of splitting on quality attributes (cooking time, culinary and organoleptic and mould infection).

d. **Hypotheses:** (1) Development of *C. maculatus* is affected by splitting cowpea seeds. (2) Quality attributes of cowpeas are improved by splitting of seeds.

e. **Description of research activity:** Laboratory studies will be conducted to determine the establishment and population build up of *C. maculatus* on split cowpeas. The generation time, number, sex, hatchability, longevity, size and fecundity of emergent adults will be determined. The effect of splitting cowpea seeds on mold infestation, cooking time, palatability and color will also be studied. Panel tests will be conducted monthly on split cowpea seed stored for up to 6 months to determine palatability. Scores will be based on Hedonic scale of 1-5.

f. **Justification**: Previous IPM CRSP work has demonstrated that splitting of cowpea seeds prior to storage caused significant reduction of bruchid damage as well as adult emergent numbers suggesting that it could be a good component of IPM for storage bruchids. However the effect of splitting on biology of *C. maculatus*, culinary and organoleptic qualities as well as market acceptability and opportunities are not well understood. A study on splitting cowpeas, is therefore necessary to fill in these knowledge gaps.

**g.** **Relationship to other CRSP activities**: This activity is related to other IPM CRSP Research on post-harvest management of cowpea in Uganda.

**h.** **Progress to**-date: New activity

**i.** **Projected Outputs:** (1) Knowledge on the biology of *C. maculatus* on split cowpeas; (2) Proocessing, storage, utilization and marketability of split cowpeas.

**j.** **Projected impacts:** Livelihoods of farmers in terms of food security, good nutrition and raised incomes improved.

**k.** **Project Start date:** September 2002

**l.** **Projected Completion:** October 1, 2003

**m.** **Projected Person Months of scientists time per year:** 12 man- months

**n.** **Budget:** Makerere/NARO – $3,850; Virginia Tech/OSU (see IV.1).

## IV. Socioeconomic Assessment of IPM CRSP Technology Development, IPM and GIS Dissemination and Symposium Proceedings Support

### IV.1. Socioeconomic Assessment of IPM CRSP Technology Development Activities in Uganda

**a.** Scientist(s) Names and Institutional Affiliations: *Principal Investigators:* V. Kasenge, W. Ekere, J. Bonabana,[1] B. Mugonola,[2] P. Kibwika, M. Amujal[3] – Makerere University; V. Odeke, E. Mwanja – Uganda Extension Crop Protection Specialists; Daniel B. Taylor – Virginia Tech; J.M. Erbaugh – Ohio State. *Collaborating Scientists*: S. Kyamanywa, A. Kaaya, C. Akemo, E. Adipala – Makerere University; G. Bigirwa, B. Sekamatte, J. Olupot, A. Agona - NARO; H. Warren, G. Luther – Virginia Tech.

**b.** **Status:** New and Continuing[4] Activities

**c.** **Overall Objective(s):** The overall purpose of this research is to assess the economic impacts of IPM CRSP activities in Uganda at: the level of the individual production

[1] She began her M.S. program at Virginia Tech in August 2000.
[2] He began his postgraduate studies at Makerere University in September of 2000. Upon completion of his M.S. thesis in September 2002, he will be hired as a research assistant to work on IPM CRSP economic analyses.
[3] She began her postgraduate studies at Makerere University in September of 2001.
[4] Given the cropping seasons in Uganda, and the IPM CRSP's fiscal year, many of the analyses for the second cropping season cannot be completed until after the start of the new IPM CRSP fiscal year.

activity, farm, region, nation, and beyond as appropriate.[5] Resource limitations prevent comprehensive evaluation of all technologies at all levels. We will attempt to evaluate all promising technologies at the individual production activity level, while only a few technologies will be subjected to a more comprehensive analysis. **Objectives for the coming year:** (1) to evaluate the farm level economics impacts of IPM packages on maize, groundnuts and cowpeas; (2) to assess factors influencing the adoption of IPM CRSP packages for groundnuts, sorghum and cowpeas; (3) to analyze the tomato marketing system including assessing the effect of visible pesticide residue on sales of tomatoes; and (4) to evaluate consumer acceptability of split cowpeas in the market.

d. **Hypotheses:** Adoption of IPM CRSP technologies is inversely related to farmers' age. Adoption is directly related to farm size (or per capita farm size), income and education level. Women are less likely to adopt IPM technologies than men. IPM CRSP technologies are profitable.

**e. Description of Research Activity (approach):**

New Activity A production function will be estimated for Maize production in eastern Uganda. Optimal input use will be determined, and the influence of risk on input use will be assessed (B. Mugonola,[6] V. Kasenge, G. Bigirwa). In an extension of the pilot marketing study conducted last year, an in depth marking study of peri-urban tomato production will be conducted. Of continued interest is the effect of visible pesticide residue on tomato sales. Some say it enhances their sales, as some people perceive them to be of higher quality with residue – others say that the residue decreases sales because consumers are concerned about the health impacts of pesticides. Vendors, suppliers, market overseers and consumers will be interviewed. The interviews will be conducted in four seasons, central and satellite markets in each of the 5 divisions of Kampala in both big and small markets in each division (V. Kasenge, B. Mugonola, A. Kaaya). Samples of tomatoes have been collected for pesticide residue testing, and the tests will be conducted shortly. Splitting cowpeas before storage is a promising technique for post harvest *Bruchid* control. The acceptability of split cowpeas in the market will be assessed. Sales of the split cowpeas in markets in Kumi will be evaluated with both loose and bagged cowpeas compared to whole loose cowpeas (J. Bonabana, B. Mugonola, A. Kaaya, A. Agona, E. Adipala). The economic impact of the use of fish baits and intercrops to attract predatory ants in controlling termites in Maize will be evaluated (W. Ekere, B. Mugonola, B. Sekamatte, S. Kyamanywa).

Continuing Activity. A survey will be conducted in Kumi District to assess factors influencing the widespread adoption of pest management packages generated by the CRSP for sorghum, groundnuts and cowpeas. A random sample of both men and women farmers will be surveyed (J. Bonabana,[7] D. Taylor, M. Erbaugh, V. Odeke). In addition the influence of farmer field schools on IPM cowpea technology adoption will be

[5] Currently, with the possible exception of some seeds and some planting materials the free market, without government intervention, provides inputs.

[6] B. Mugonola's M.S. thesis. Following completion of this thesis, he will be hired as a research project for the next year of the project.

[7] Her M.S. thesis.

assessed (M. Erbaugh, P. Kibwika, E. Mwanja).[8] The assessment of the cost effectiveness of management practices for pest and disease control on cowpeas in the field, and their implications for post harvest storage will continue (B. Mugonola, A. Agona, E. Adipala, S. Kyamanywa). Striga control treatments on sorghum including the seed treatments and intercropping will continue to be assessed with partial budgeting (W. Ekere, J. Olupot). At the suggestion of biological scientists, the economic analysis of the impact of IPM CRSP activities on groundnut production will continue for one more year (J. Bonabana, E. Adipala, S. Kyamanywa, G. Luther, H. Warren)

f. **Justification:** IPM CRSP interventions must be evaluated from both a biological science and an economic perspective. It is possible that interventions viewed favorably from a biological perspective, will not be economically viable. Conversely, it may the case that interventions that do not appear to be superior from a biological perspective, are profitable from an economic perspective if they sufficiently reduce production costs and/or the risks of production (as was demonstrated in our post-harvest storage work). Socio-economic research is essential to assess profitability of technologies and impacts on food security, poverty reduction and sustainable resources use. The basic economic analyses are crucial components in the assessment of the economy wide impacts of IPM CRSP activities as well as their potential spillover effects. Given the complexity of factors influencing agricultural production and marketing, substantial empirical research is still needed to investigate the feasibility and social acceptance of IPM CRSP technologies in Uganda.

g. **Relationship To Other IPM CRSP Activities:** As indicated in the discussion of new and continuing activities above, interaction will take place with many of the biological scientists involved in some aspect of IPM CRSP research. While resource limitations preclude an economic assessment of every aspect of the project, the majority of the project's activities will undergo some form of economic evaluation.

[8] M. Amujal's M.S. thesis.

**h. Progress to Date:** Data collection has been partially completed for the economic assessment of sorghum trials. Jackline Bonabana, Basil Mugonola, and Magdalena Amujal have developed their M.S. thesis proposals, and have begun their research. A preliminary cost-benefit analysis of the impact of predatory ants on termite damage to maize fields was conducted. Field data collection forms are being finalized. Field level economic impacts of IPM CRSP technology on cowpeas have been assessed, and the analysis will now be expanded to post harvest impacts. The economic assessment of tomato production has been completed. Papers are being prepared for publication on the farm level impacts of IPM CRSP technologies on groundnuts and cowpeas, potato, and tomato. A paper entitled "The Economic Importance of Farm Level Bruchid Control in Stored Dry Beans and Cowpeas in Uganda" has been published in *MURIK Bulletin*, V2. Another paper "Farm Level Evaluation of Monocropping and Intercropping Impacts on the Returns to Maize yields in Iganga," has been published in *East African Journal of Rural Development*, V17.

**i. Projected Outputs:** (1) Journal articles are being submitted on the economics of IPM CRSP interventions on groundnut, tomato, potato, and cowpea production. (2) Three Ugandans will receive M.S. degrees - one from Virginia Tech, and two from Makerere University, completing studies on IPM technology adoption, impact of farmer field schools, and the economics of Maize production. (3) Papers will be presented at professional meetings and submitted for publication as the opportunities arise.

**j. Projected Impacts:** The impact assessment work will provide a framework for further impact assessment of technologies developed by the IPM CRSP in Uganda. Multi-disciplinary collaboration between social scientists and biological scientists will be enhanced. The analyses will provide information on socially acceptable and economically viable technologies.

**k. Projected Start:** September 29, 2002

**l. Projected Completion:** Continuing activity: December 31, 2002; New activity: September 28, 2003

**m. Projected Person-Months of Scientists time per Year:** 24

**n.** Budget: Makerere – $15,765; VT – $21,133; OSU – $5,820

## IV.2. IPM Information Development and Transfer: Assessment of Extension Staff Knowledge of IPM

**a. Scientist(s) Names and Institutional Affiliations**: Paul Kibwika - Dept. of Ag. Extension Educ., Makerere University; Mark Erbaugh - The OSU; Edison Mwanje - Extension Agent, Iganga District; Valdo Odeke - Extension Coordinator, Kumi District.

**b.** **Status**: Continuing Activity

**c.** **Overall Objective**(s): (1) Develop a survey and instrument and sampling frame; and (2) Conduct a survey in 10 districts of extension agent awareness and knowledge of IPM.

**d.** **Hypotheses**: The hypothesis that will guide this study is that extension agents are not knowledgeable of IPM and related knowledge. A sub-hypothesis is that extension agent background characteristics (age, education level, experience, gender, occupational status (rank), contact with NGO are positively associated with knowledge of IPM.

**e.** **Description of Research Activity**: A survey of 200 extension agents in 10 districts of Uganda will be conducted late 2002 or early 2003. The survey instrument will draw from questions used to assess extension agent knowledge of IPM in Iganga. The sampling frame will be randomly selected from lists of extension agents available at the district level. All questionnaires will be completed individually by extension agents at group meetings in each district.

**f.** **Justification:** "Failure of most IPM programs is a deficiency in extension particularly education and awareness of IPM technology" (Morse and Buhler, 1997). The current level of IPM knowledge among extension agents in Uganda is not known. A pilot assessment of extension agent knowledge and awareness of IPM was conducted with 8 extension agents in Iganga/Mayuge, in March 2001. This study indicated that extension agents had a limited awareness of IPM and a moderate level of IPM knowledge. This level of knowledge is considered inadequate if IPM is going to be institutionalized and disseminated to a larger audience in Uganda. Thus, this survey seeks to provide a more comprehensive assessment of extension agent knowledge and knowledge gaps of IPM. Information derived from the survey will help plan and target future IPM training for extension agents.

**g.** **Relationship to other CRSP activities at the site**: This work relates directly to Uganda Site efforts to disseminate IPM and IPM CRSP technologies to a broader audience.

**h.** **Progress to date**: A pilot assessment of extension agent knowledge and awareness of IPM was conducted with 8 extension agents in Iganga/Mayuge, in March 2001. This study indicated that extension agents had a limited awareness of IPM and a moderate level of IPM knowledge.

**i.** **Projected Output(s):** (1) A journal article for either African Crop Science Journal or East African Journal of Rural Development; (2) PhD dissertation at Penn State University.

**j.** **Projected Impacts**: Information derived from the survey will help develop training plans that for future IPM training programs for extension agents.

**k.** **Projected Start**: October 1, 2002

l. **Projected Completion**: September 1, 2003

m. **Projected Person-Months of Scientists Time per Year**: 3-4

n. **Budget**: Uganda – $5,665; OSU – $3,000

**IV.3 Support for International Conference on IPM in Sub-Saharan Africa**

a. **Scientists:** Site Chair, Coordinator and Symposium Coordinator

b. **Status:** continuing

c. **Objective:** Post conference support to edit and publish proceedings and promote regionalization.

d. **Hypothesis:** N/A

e. **Description of Activity:** A special edition of the African Crop Science Journal will be produced following the symposium

e. **Justification:** An IPM symposium in Uganda is considered important at this junction in order to facilitate scientific synergism and promote regional collaboration**.**

f. **Relationship to other CRSP activities:** Will provide a platform for discussing IPM in sub-Saharan Africa.

g. **Progress to date:** The symposium dates are set for September 8-12, 2002

h. **Expected outputs:** The proceedings will represent the symposium output, will spread the results of the symposium, and further regionalization of the IPM CRSP.

i. **Expected impacts:** Enhanced regional attention and awareness of IPM

j. **Projected Start:** October 2002

k. **Projected Completion:** May 2003

l. **Person months:** N/A

m. **Budget: $6,600**

**IV.4 Geographic Information Systems To Enhance IPM Collaborative Research in Uganda: Follow-up to Solidify GIS Knowledge and Skills**

a. **Scientist(s) Names and Institutional Affiliations**: E.A. Roberts (Virginia Tech); L.S. Grossman (Virginia Tech); S. Kyamanywa (Makerere University); National Agricultural Research Organization.

b. **Status: New or Continuing Activity:** Continuing

c. **Overall Objective(s):** The purpose of this project is to provide continuing Geographic Information Systems (GIS) support to collaborating agricultural scientists in Uganda. This will be done by building on the foundation for implementing GIS as a functional component of pest management research in Uganda which was laid by the authors in a three-day workshop conducted in Kampala in February of 2002. In follow up visits, an experienced GIS professional will work closely with a small number (5 or 6) of researchers to address the use of GIS in their individual projects. Training options include small informal group sessions, informal consulting with individuals, and field visits with researchers to assist with the collection of spatial data and to consult on possible GIS applications in individual projects. The Ugandan researchers who would be chosen for this continued training should be selected from those who participated in the original workshop and are using GIS or show promise for GIS in their programs.

d. **Hypotheses:** (1) skills learned in a workshop setting need to be cultivated in a more intense learning environment that focuses on individual projects. (2) continued interaction with those initial workshop participants who are actually using GIS will cement their use into the researchers' repertoire of analytic tools.

e. **Description of Research Activity:** No research. Informal student tutorial sessions in a one-on-one or small group format.

f. **Justification (relation to IPM-CRSP objectives and priorities):** While short intense workshops of the kind presented in 2002 are a good forum to expose researchers to GIS tools and concepts, experience has shown that users often become overwhelmed, frustrated, and confused when applying these tools to actual field problems, resulting in high rates of attrition. Previous experience with GIS implementation funded by the IPM CRSP in Jamaica demonstrates the benefit from having post-training visits to individuals learning these tools. In addition, experience has shown that only a fraction (15 to 25%) of original participants continue using the tools. It is these few who deserve continued support. Follow-up visits to training sites also helps local users to broaden their grasps of associated tools and concepts such as data management as well as the procurement of data.

g. **Relationship to other CRSP activities at the site:** Use of GIS will complement and enhance the work of those currently focusing on the introduction of resistant varieties, the factors affecting pest outbreaks (such as the groundnut leaf miner), the socio-economic influences on IPM adoption, and pest problems associated with crop storage, as well as other research issues related to IPM.

h. **Progress to date:** In February of 2002, Lawrence Grossman and Andy Roberts of

Virginia Tech presented an intense 4-day GIS workshop with 16 participants from Uganda and one from Democratic Republic of Congo. The groundwork for this workshop had been laid in March 2001 when Grossman visited Uganda to discuss plans, meet cooperators, and collect data.

**i.** **Projected Outputs:** Enhancement of both knowledge base and skill sets in GIS along with experience in using these tools for

**j.** **Projected Impacts:** Continued training in the techniques of GIS and GPS will address the following needs: (1) provide a database system for managing and storing IPM data; (2) enhance analysis of data to reveal relationships among variables; (3) encourage scientists to think and interpret their data from a spatial perspective; (4) stimulate hypothesis formation to facilitate additional research; (5) increase the ability to visualize relationships among variables; (6) combine environmental, agricultural, and socio-cultural data in analyses; and (7) improve the ability of scientists to communicate and share the results of their research.

**k.** **Projected Start:** October 1, 2002

**l.** **Projected Completion:** September 30, 2003

**m.** **Projected Person-Months of Scientists Time per Year:** 1 month

**n.** **Budget:** $4,000 – Virginia Tech

## V. IPM CRSP Uganda Site Emergency Response Work Plan - Coffee Wilt

### Etiology, Epidemiology and Integrated Management of Coffee Wilt *(Fusarium xylarioides* (teleomorph = Gibberella xylarioides)

Dr. Sally Miller, Plant Pathologist, The Ohio State University
Ms. Melanie Ivey, Plant Pathologist, The Ohio State University
Dr. J. Mark Erbaugh, IPM CRSP Uganda Site Chair, The Ohio State University
Dr. Herman Warren, Plant Pathologist, Virginia Tech

**Introduction:** Coffee is the dominant commodity in Uganda's economy. The crop provides employment and income to 2.5 million Ugandans and continues to be the major foreign currency earner, accounting for 51% of total export in 1997. Coffee wilt caused by *Fusarium xylarioides* came into Uganda in 1993. It has spread at an alarming rate and is now known to be present in 25 districts. In some districts, 40-50% of the robusta coffee trees have been affected, and some fields have been completely destroyed and abandoned. The most promising approach to control this disease is development of resistant cultivars, and fortunately, it appears that sources of resistance are available. The information generated by activities contained in this work plan will be of great utility to breeders and others attempting to develop alternative control practices.

USAID/Kampala and the Ugandan National Agricultural Research Organization (NARO) requested emergency assistance from the IPM CRSP to help find solutions to the new and devastating disease of robusta coffee: Coffee Wilt (*Fusarium xylarioides*). From October 9 –21, 2000, a three person team fielded by the IPM CRSP, worked closely with NARO scientists at the Coffee Research Institute (CORI), to develop specific research plans and budgets that would address gaps in knowledge of the Etiology, Epidemiology and Integrated Management of Coffee Wilt (*Fusarium xylarioides*). The draft work plan and budget presented below is the product of this combined effort by the IPM CRSP and CORI team. These ideas were fully vetted in subsequent meetings with the NARO Director General, USAID/Kampala, and the Uganda Coffee Development Authority.

**Acknowledgements**: The IPM CRSP team would like to express its appreciation to USAID/Kampala and the IPM CRSP Management Entity for providing funding support and to NARO for providing complete and comprehensive facilitation and cooperation. In particular, we would like to acknowledge the efforts and contributions by Mr. Pascal Musoli, Coffee Breeder, and Dr. Georgina Hakiza, Interim Director, and Plant Pathologist, both of the Coffee Research Institute (CORI).

**Etiology, Epidemiology and Integrated Management of Coffee Wilt**

**1.1 Etiology of Coffee Wilt**

**a. Scientists:**

| | |
|---|---|
| Dr.G.J. Hakiza | Pathologist (lead scientist) |
| Dr. A. Kangire | Pathologist |
| Dr. S. Miller | Ohio State University |
| M. Ivey | Technician OSU |
| P.C. Musoli | Breeder |
| Dr. D. Kyetere | Breeder |
| P. Aluka | Breeder |
| S. Olal | Technician |
| C. Kabole | Technician |

**b. Objectives:** Coffee wilt is caused by Fusarium xylarioides (teleomorph = Gibberella xylarioides). DNA typing done by the International Mycological Institute indicates that the strain, which attacks arabica coffee in Ethiopia, is different from the strain, which attacks robusta coffee in Uganda. This research will provide information on the differences in *F. xylarioides* strains found in Uganda.

**c. Hypothesis:** In different districts in Uganda, there are different strains of *Fusarium xylarioides* that vary in their aggressiveness to different robusta genotypes.

**d. Description of Research Activity:** Specimens showing coffee wilt symptoms will be obtained from ten districts, selected west to east, across Uganda, and *F. xylarioides* will be isolated from samples. Cultures of the fungus from each district will be used to inoculate cuttings from five robusta cultivars that differ in susceptibility to coffee wilt based on previous tests and one arabica cultivar. A Ugandan scientist will take strains of the fungus showing differences in aggressiveness to robusta coffee to a laboratory in the U.S.A for DNA typing and learning the techniques used in this process. These strains will be compared with strains found in other countries.

**e.** **Justification:** Relatively little is known of different strains of *Fusarium xylarioides* that cause coffee wilt. Coffee breeders need information on differences in aggressiveness of strains of this fungus to robusta coffee. It is possible that resistance in lines developed during breeding could be overcome by changes in the genotype of the fungus. Coffee breeders need the ability to distinguish strains of *Fusarium xylarioides* by DNA typing to more readily detect genetic changes in the fungus.

**f**. **Project output:** Information will be obtained on *Fusarium xylarioides* strains currently in Uganda.

**g**. **Project impact:** Information on different strains of the coffee wilt fungus is needed by coffee breeders to develop resistant cultivars.

**1.2 Epidemiology of Coffee Wilt**

**a.** **Scientists**:

| | |
|---|---|
| Dr.G.J. Hakiza | Pathologist (team leader) |
| Dr. A. Kangire | Pathologist |
| P.C. Musoli | Breeder |
| Dr. D. Kyetere | Breeder |
| M.P.E Wetala | Agronomist |
| Dr. Herman Warren | Virginia Tech |
| Dr. Ira Deep | The Ohio State University |
| S. Olal | Technician |
| C. Kabole | Technician |

**b.** **Objectives**: Investigations on inoculum source and spread of coffee wilt disease will determine whether the pathogen is (1) soil borne (2) seed borne (3) produced on infected stems, leaves, husks (4) from alternative hosts such as banana and wild coffee, and /or transmitted by insects.

**c.** **Hypothesis:** The spread of coffee wilt disease to healthy coffee plants is the result of inoculum coming from one or more sources. Inoculum may be found in soil or infected seeds, produced on infected plant parts, may come from alternative hosts found near the healthy plants or may be carried to healthy plants by insect vectors.

**d.** **Description of research activity:**
***Study 1.2a***. Several techniques are available to determine whether soil is infested with the coffee wilt pathogen, *Fusarium xylarioides.* A biological assay will be conducted using coffee seedlings to trap the fungus. Five trees that have been killed by coffee wilt will be taken out, and soil samples will be collected from the root area within one week.

Coffee seedlings will be planted using controls and replication as needed. This process of sampling and assaying soil at these five tree sites will be repeated at one-month intervals until the fungus is no longer obtained.

***Study 1.2b.*** Coffee seeds collected from ten trees that have been killed by coffee wilt will be plated out on agar medium to determine the presence of *Fusarium xylarioides.* Two hundred seeds taken from each of the ten trees will be assayed.

***Study 1.2c***. Experiments will be setup to determine whether macroconidia of *Fusarium xylarioides* can be produced on stems, leaves or seed husks of coffee wilt infected trees and therefore serve as inoculum. Stems collected from ten coffee trees infected with wilt will be placed in a moisture chamber for 48 hours and examined for presence of macroconidia of *F. xylarioides.* Leaves from these ten trees will be treated in the same manner. Seed husks from coffee wilt infected trees will be surface sterilized and plated out on agar media to determine the presence of *F. xylarioides.* A Master's Degree Student in the Department of Crop Science, Makerere University will investigate the sources of *F. xylarioides* inoculum in infected coffee plantings: stems, leaves and seed husks.

***Study 1.2d.*** The coffee wilt fungus, *Fusarium xylario*ides, can attack all species of coffee and the fungus has been reported to attack bananas. Five coffee plantings will be located in which trees in the plantings are dying of coffee wilt and a forest is nearby. In each planting an area 100 meters into the forest will be surveyed for presence of wild coffee trees that are infected with coffee wilt. Samples from suspected trees will be collected, brought to the laboratory, and assayed for presence of *F. xylarioides*. Five coffee plantings will be located in which banana trees are interplanted with coffee and trees are dying from coffee wilt. Each planting will be surveyed for presence of banana plants that are infected with *F. xylarioides*. Suspected samples will be collected, brought to the laboratory, and assayed for presence of the fungus.

***Study 1.2e.*** To determine whether insects may transmit the pathogen, insects will be collected from coffee plantings where coffee is infected, plated out on differential agar media that favor *Fusarium* species and cultures identified.

***Study 1.2f.*** In naturally infected coffee fields on-farm and on-station at CORI, 128 (8x16) coffee trees will be marked for observation and recording at 4 weekly intervals. Initially, the health status of all 128 trees marked will be recorded. The pattern of wilt spread from tree-to-tree will be indicated at each recording. Presence of the pathogen with increasing distance from infected trees and with depth in soil will be established. Spores will be trapped using greased glass slides placed at variable heights in coffee fields at Kituza to assess spore dispersal. Other information to be collected will include geographical location, altitude, management practices, slope of land, and soil type.

**e.** **Justification:** This research will attempt to determine the sources of inoculum that initiate the disease in a planting, and that provide for subsequent spread of disease throughout the planting. Establishment of the disease in a planting commonly leads to death of all the trees. Knowledge of source of inoculum will lead to better disease management through changes in cultural practices.

**f.** **Project output:** Increased knowledge of the Epidemiology of this disease will be obtained.

**g.** **Project impacts:** Knowledge of sources of inoculum for both primary and secondary infection will be helpful to breeders and may help in cultural control of the disease.

## 1.3 Host-parasite relationship

**a.** **Scientists**:

| | |
|---|---|
| Dr.G.J. Hakiza | Pathologist (Lead scientist) |
| Dr. A. Kangire | Pathologist |
| P.C. Musoli | Breeder |
| Dr. D. Kyetere | Breeder |
| P. Aluka | Breeder |
| Dr. Herman Warren | Virginia Tech |
| Dr. Ira Deep | Ohio State University |
| S. Olal | Technician |
| C.Kabole | Technician |

**b.** **Objectives:** To determine the methods of penetration, infection and invasion of coffee plants by *Fusarium xylarioides* by examining: (1) the point of infection; (2) invasion of host tissue following penetration; and (3) the relationship of age of tissue to infection.

**c.** **Hypothesis:** During development of coffee wilt disease, (1) points of infection include roots, stems and/or leaves; (2) the fungus moves into different tissues in the plant; (3) rapidity of invasion of host tissue by the fungus is related to age of coffee trees.

**d.** **Description of research activities:**
***Study 1.3a.*** Genotypes with varying degrees of susceptibility will be inoculated with a spore suspension ($1.3 \times 10^6$) of *Fusarium xylarioides*. Five cuttings of each genotype will be sprayed with inoculum and placed in a moisture chamber for 36 hours in the screen house. Treatments will consist of wounded and unwounded stems, leaves, and roots. Ten samples from each treatment will be examined with the microscope to determine visually if penetration and growth of the fungus occurs. Two weeks after removing plants from the moisture chamber 20 sections of stems, leaves and roots will be plated on agar medium and observed for *F. xylarioides*.

***Study 1.3b.*** Tissue from plants that have been infected by the fungus will be examined microscopically for growth and development of the fungus in the tissue. Diseased host tissue will be sectioned, stained and examined for fungal mycelium and propagules in the xylem, phloem, cambium and cortex to determine what host tissues are invaded. A Master's Degree student in the Department of Crop Science, Makerere University will determine which coffee tissues are invaded by F. xylarioides: roots, stems, leaves –

xylem, phloem, cambium, cortex.

***Study 1.3c.*** Ten plants from three genotypes with varying degrees of susceptibility will be studied from flowering period to harvest. Tissues will be examined at the onset of flower budding, mid maturity, prior to harvest and two months after harvest. A monitoring system that consists of fields with different ages of plants will be observed for symptom development. One hundred trees will be tagged and plants in each age group observed for disease development. The incidence of diseased plants will be recorded.

***Study 1.3d***. A study conducted in an established coffee planting will demonstrate whether penetration may occur through wounds created during weeding and pruning. Treatments will include creating wounds by mechanically chopping out weeds thus creating wounds in roots near the soil surface versus weeding by use of herbicides or mechanical action that does not wound the roots. Treated root surface areas will either be inoculated with *F.xylariodes* macroconidia or left uninoculated. It is common to prune out new stems coming from adventitious buds at the base of the tree. The wounded areas of the tree will be tagged and examined later for presence *of F. xylarioides* by culturing the fungus.

***Study 1.3e***. Studies will be carried out to determine whether factors such as temperature, light, surface wetness, pH, affect spore germination, germ tube growth and penetration of host tissues. Stem sections of 3-6 months old coffee seedlings inoculated with *F. xylarioides* will be stained and examined for post penetration events such as formation of barriers, toxins, etc., within the host tissues. The specimens will be sectioned after 2 hours, 2 weeks, 4 weeks, at symptom appearance and at an advanced stage of disease development.

**e.** **Justification:** There is little information on host-parasite interactions. This research will determine how the fungus penetrates and invades the host tissue. The information will aid pathologists and breeders in development of control strategies.

**f.** **Project output:** Points of infection and invasion will be determined; this knowledge will contribute to development of rapid methods for evaluation of germplasm and development of an overall management scheme to control coffee wilt.

**g.** **Project impact**: Development of management practices to control coffee wilt will result in higher income and security for small-scale farmers.

## INTEGRATED PEST MANAGEMENT – COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), AFRICA SITE IN UGANDA

(October 1, 2002 – September 30, 2003)

| ACTIVITY | SCIENTISTS | BUDGET ($) |
|---|---|---|
| **HIGH COMMERCIAL VALUE LEGUME CROPS ASSOCIATED WITH HIGH PESTICIDE USE** | | |
| I.1.1 Integrated Management of Cowpea Insect Pests and Diseases | E. Adipala, S. Kyamanywa – Makerere; G. Luther, – VA Tech.; J. Mbata – FVSU; R.B Hammond, M. Erbaugh – OSU. | Makerere $ 14,060<br>OSU $ 3,780<br>VA Tech $ 2,937<br>FVSU $ 8,450 |
| I.1.2 Integrated Management of Groundnut Insect Pests and Diseases | E. Adipala, S. Kyamanywa – Makerere; G. Luther – VA Tech; A. Agona –NARO/KARI; C. Busolo-Bulafu, Kumi; R.B. Hammond, M. Erbaugh – OSU. | Makerere $ 22,530<br>OSU $ 3,906<br>VA Tech $ 2,809 |
| **IMPORTANT CEREAL CROPS ASSOCIATED WITH FARMING SYSTEMS IN EASTERN UGANDA** | | |
| I.2.1 Integrated Pest and Disease Management Strategies for Maize In Uganda | G. Bigirwa, Kalue, Sekamati – NARO/NAARI; R.C. Pratt, R. Hammond – OARDC, OSU; E. Adipala – Makerere. | Makerere $ 13,805<br>OSU $ 21,672 |
| I.2.4 Development of novel options for *Striga* management for small holder sorghum farmers | J.R. Olupot – SAARI/NARO; H. Warren – VA Tech. | Makerere $ 5,458<br>OSU $ 6,002 |
| **DEVELOPMENT OF IPM STRATEGIES FOR HIGH VALUE HORTICULTURAL CROPS** | | |
| II.1.1 Development of IPM Technologies for Tomato Production in Central Uganda | M.C. Akemo, S. Kyamanywa – Makerere; R. Hammond, Grewal – OSU; V. Kasenge – Makerere; M. Olanya – CIP. | Makerere $ 15,147<br>OSU $ 7,560 |
| **POST-HARVEST MANAGEMENT OF MOULDS AND MYCOTOXINS IN MAIZE AND GROUNDNUTS** | | |
| III.1.1 Moulds and Mycotoxins in Maize and Groundnuts in Uganda | A.N. Kaaya, E. Adipala, S. Kyamanywa – Makerere; H. Warren – VA Tech; A. Agona – KARI; G. Bigirwa – NAARI. | Makerere $ 8,806<br>VA Tech $ 14,875 |
| III.2.1 Splitting Cowpea effect on biology of C. maculates, quality attributes and marketability of cowpea seeds. | A. Agona, S. Kyamanywa, A.Kaaya, H. Warren, J. Bonabana, V.Kasenge, W.Ekere, M. Erbaugh & D. Taylor | Makerere $ 3,850<br>VT & OSU (see socio-econ. Below). |

| | | | |
|---|---|---|---|
| **SOCIO-ECONOMIC ASSESSMENT, INFORMATION DISSEMINATION AND REGIONALIZATION** | | | |
| IV.1 | Socioeconomic Assessment of IPM CRSP Technology Development Activities in Uganda | V. Kasenge, W. Ekere, J. Bonabana, B. Mugonla, Ogwang – Makerere; V. Odeke – Extension Crop Protection Specialist; D.B. Taylor – VA Tech; J.M. Erbaugh – OSU; | Makerere $ 15,765<br>VA Tech $ 21,133<br>OSU $ 5,820 |
| IV.2 | IPM Information Development and Technology Transfer | P. Kibwika – Makerere; M. Erbaugh – OSU; Dan Taylor – VA Tech; S. Kyamanywa – Makerere; G. Luther – VA Tech. | Makerere $ 5,665<br>OSU $ 3,000 |
| IV.3 | Regional IPM CRSP Symposium | E. Sabiiti, S. Kyamanywa – Makerere; G. Bigirwa, – NARO; C. Omwega – ICIPE; A. Ekwamu – Rockefeller Forum. | Makerere $ 8,800 |
| IV.4 | Geographic Information Systems To Enhance IPM Collaborative Research in Uganda | E.A. Roberts, – VA Tech; S. Kyamanywa – Makerere; NARO | Makerere $ 1,375<br>VA Tech $ 5,108 |
| **COFFEE WILT** | | | |
| I.1 | Etiology of Coffee Wilt | G.J. Hakiza – CORI; S. Miller, M. Ivey – OSU. | CORI $ 19,195<br>OSU $ 27,849 |
| I.2 | Epidemiology of Coffee Wilt | G.J. Hakiza, D. Kyetere – CORI; H. Warren – VA Tech. | CORI $ 35,541<br>VA Tech $ 8,979 |
| I.3 | Host-Parasite Relationship | G.J. Hakiza, D. Kyetere – CORI; H. Warren – VA Tech. | CORI $ 28,133<br>VA Tech $ 15,304 |

# Year 10 Work Plan for the Eastern Africa Site in Uganda

Year 10 IPM CRSP activities at the African Site in Uganda will focus on five topical areas. First, research activities to refine and disseminate development of IPM packages for important legume (cowpea and groundnuts) and cereal crops (maize and sorghum) with transition farming systems in Eastern Uganda will be concluded. Second, the development of IPM packages for the high-value horticultural crop, tomato, will continue. 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. Third, in order to develop appropriate post-harvest management options to reduce the incidence of moulds and mycotoxins on maize and groundnuts, work will continue on determining harvesting, drying, shelling and storage regimes of these commodities at both the farm and market. Fourth, socioeconomic assessment activities will evaluate the farm level economic impacts of IPM packages on maize, cowpea and groundnut; assess factors influencing the adoption of IPM CRSP packages for groundnuts, sorghum and cowpea; analyze the tomato marketing systems; and, assess extension agent knowledge of pest management and IPM as a way to further disseminate IPM and IPM CRSP recommendations. The proceedings of an IPM CRSP Symposium to be held in Uganda during Year 9 will also be assembled and published and additional regional participation pursued. Finally, an affiliated activity with funding from USAID/Kampala and the IPM CRSP Management Entity (ME) that is investigating the etiology, epidemiology and integrated management of coffee wilt (*Fusarium xylariodes* (telemorph=Gibberella xylarioides), will be concluded.

The IPM CRSP research team in Uganda is composed of scientists from each of the major research institutions located in the country including Makerere University's Faculty of Agriculture, and the three research institutes associated with the National Agricultural Research Organization (NARO): Kwanda Agricultural Research Institute (KARI), Namulonge Agricultural Research Institute (NARI), the Serere Agricultural and Animal Research Institute (SAARI), and the Coffee Research Institute (CORI). On-farm research activities are facilitated by extension agents and farmer associations at research sites in Iganga, Kumi, Mpigi and Pallisa districts. Also, there are four Makerere University graduate students contributing to field research efforts. Three Ugandan graduate students will complete their course training in the USA.

The eight collaborating research scientists from the USA are drawn from three institutions: Virginia Tech, The Ohio State University and Fort Valley State College. This multi-disciplinary and institutional effort is coordinated by the Site Chair located at The Ohio State University; the Site Coordinator located at Makerere University and the Deputy Site Coordinator located at NARI. Additional institutions contributing to the IPM CRSP research effort in Uganda are the Rockefeller Research Forum, and the International Center for Insect Physiology and Ecology (ICIPE). Four of the IARCs are participating through germplasm contributions including IITA, CIP, ICRISAT and CIMMYT/Harare.

**I. High Commercial Value Legume Crops associated with High Pesticide Use.**
Activities in this section focus on cowpea and groundnuts that are important food

security and cash crops in Eastern Uganda. The production of each of these crops is associated with frequent and often excessive use of synthetic pesticides.

### I.1.1 Integrated Management of Cowpea Insect Pests and Diseases

**a.** **Scientists**: E. Adipala; S. Kyamanywa; W. Ekere; P. Kibwika - Makerere University; G. Luther and H. Warren - Virginia Tech.; J. Mbata - Fort Valley ***State*** University, USA; G. Epieru, A. Agona, NARO; V. Odeke, DAO's Office, Kumi; E. Iceduna, DAO's Office, Pallisa; R.B Hammond and M. Erbaugh - Ohio State; Okoth, Graduate and ***Undergraduate*** students - Makerere University

**Collaborators**: Rockefeller Foundation (Forum) [cost sharing on M.Sc. student for local networking and scaling-up].

**b.** **Status**: Continuing research with new activities.

**c.** **Objectives**: The overall objective is to reduce and rationalize pesticide usage on cowpea in Eastern Uganda. The specific objectives are: (1) to scale-up dissemination of IPM technologies; (2) to refine IPM options by (a) to integrate synthetic and biorationals for management of field pests and bruchids (b) to validate EILs and action thresholds of flower thrips, aphids and pod borers to guide insecticide application on-farm; (3) to determine the effectiveness of predators and parasitoids of cowpea insect pests, (4) to determine the efficacy of pheromone baited trapping and use of parastoids in the management of cowpea beetles (*Callosobruchus* spp.) in the field.

**d.** **Hypotheses**: (1) An IPM strategy, involving close spacing, early planting and strategic insecticide application based on will control cowpea pests. (2) Integration of synthetics and biorationals is beneficial in the management of field pests and bruchids. (3) There is a level of population density below which thrips, aphids and podborers do not cause yield loss in cowpea. (4) There are predators and parasitoids that exert significant biological control pressure on some major insect pests of cowpea in Uganda. (5) Pheromone trapping will and parasitoids eliminate or reduce populations of cowpea bruchids.

**e.** **Description of Research Activity**: This activity is subdivided into four sub- activities:

<u>Dissemination and adoption of IPM technologies</u> (*continuing activity*) [Adipala-Ekwamu S. Kyamanywa, R. Hammond and M. Erbaugh]. The three most promising IPM technologies recommended for cowpea pests (***Aphis craccivora, Megalorothrips sjostedti, Clavigrara sp. and Maruca sp.)*** and diseases evaluated in year 9 will continue to be evaluated and disseminated using a modified farmer field school approach with two groups of farmers in Kumi and Pallisa districts. The treatments to be incorporated into the field design are; IPM 1, close spaced sole cowpea (30 x 20cm) and 3 sprays (once at budding, flowering & podding stages); IPM 2, cowpea/sorghum intercrop and 3 sprays; IPM 3 close spaced sole cowpea (no spraying) and the farmer traditional practice of

spraying ***pesticides*** 5 times, starting 10 days after emergence. With each farmer group a demonstration trial using a randomised block design with 2 replications will be established. Individual treatments will be on10 m. by 10m plots. Field monitoring of pests and diseases will be conducted with farmers every two weeks following seedling establishment. Data on pest and disease incidence and yields will be collected and discussed with farmers. Additionally, a cost-benefit analysis will be carried out to determine the profitability of the IPM packages.

Refining of IPM [Adipala-Ekwamu; S. Kyamanywa; A. Agona; R.B. Hammond, G. Luther and Opolot, H.N. (Okoth, MSc. Student)] (*continuing activity*). A second study will validate and incorporate EIL for thrips and action thresholds and, control of post-podding pests and bruchids using biorational products (crude extracts of tobacco, tephrosia and tagetes. Randomized block design trials with 4 replications will be established at two locations in Kumi and Pallisa districts in eastern Uganda. Individual treatments will be on 6 m. X 6 m plots. Treatments will include the following: IPM 1, sole crop cowpea sprayed 3 times with a synthetic pesticide at budding, flowering and podding; IPM 2, spray at budding, a second spray (synthetic) depending on EIL (for thrips) at flowering, and third spray at podding; IPM 3, spray at budding, second spray (synthetic) at flowering, and third spray with botanical product at podding; IPM 4, spray at budding, a second spray (synthetic) depending on EIL (for thrips) at flowering; and third spray with botanical at podding. Fields will be monitored through out the growing season. The effect of botanicals on predators and other beneficial insects at the budding, flowering and podding stages will be determined. The economic aspects of these alternatives will also be evaluated.

Determine effectiveness of predators and parasitoids of insect pests on cowpea (S. Kyamanywa, G. Luther, R. Hammond and T. Munyuli (MSc. Student).

Predators. Effectiveness of predation of *Coleomagilla* (Coccinellidae) will be tested *on Aphis craccivora.* Depending on availability, spiders and earwigs may also be tested as predators of aphids. Cage experiments will be set up in the field with these predator and pest species combinations to determine predation rates. Cages will be infested with a known number of predator species along with individuals of the pests species to be tested. Counts of living prey and predators will be made daily for the first 5 days, henceforth every other day until all prey are killed and consumed. Each combination of predator species and pest species will be replicated 5 times. Unknown predator species will be sent to a specialist for identification. Predator populations will be sampled in the pesticide free field described below in part b to determine their abundance and diversity in this situation.

Parasitoids. Cowpea pests will be sampled in the field to determine parasitism rates. In order to determine parasitism rates in a pesticide-free situation, cowpea will be planted in field isolated from pesticide treated fields to eliminate effect of drift and runoff on pest and parasitoids. Major cowpea pests will be sampled once per week from this field and reared in the laboratory to determine parasitism rates. All parasitoids will be identified at least to the family level and the unknown ones will be sent to a specialist for identification to species.

Field management of Cowpea bruchids (Callosobruchus sp.) using parasitoids and pheromones [G. Mbata, A. Agona, S. Kyamanywa, R.B Hammond].

Use of parasitoids (new activity). The parasitoids, *Anisopteromalus calandrae* and *Pteromalus cereallela* will be evaluated for control of cowpea seed beetle *(M. chalcosma*) in the field. Cowpea plots will be established in two sites (Kabanyolo and Kawanda). Cages will be used to contain the introduced parastoids unto the crop and will be placed in the crop a week before introducing the parastoids. The experiment will comprise of six treatments: controls (open field and caged plants with no parasitoids released), and other treatments with parasitoids released at 50% podding, pod filling, full podding and harvest maturity stages. The treatments will be replicated four times. The parasitoids to be used in this study will be from laboratory routine stock cultures. At least a minimum of five hundred parasitoids will be released for every treatment. Bruchids damage on cowpea, and *number of* parasitoid adults will be compared for the treated and control plots.

Use of pheromone baited traps. Cowpea plots will be established in two locations at Kawanda and Kabanyolo. An uncultivated plot will separate the plots. This is to minimize migration from control plot to plot dispensed with pheromone. Rubber septum will be used exclusively to dispense the pheromone. The rubber septum will be placed in *Pherocon II* diamond sticky traps. The traps containing the pheromone will be hung on pegs at the height of cowpea pods at pod filling stage. The traps will be set up at intervals of 3 m across the length and breadth of the plot. The plot will measure 50 x 50m. The pheromone septa will be replaced every week. The insects caught in the trap will be counted every week as the septa are changed. The level of infestation will be compared with that of the control that will not have traps dispensed in them.

f. **Justification**: Cowpea is the third most important legume crop in Uganda but a multitude of insect pests and the low yield potential of the local cultivars seriously curtail yields. Occasionally, diseases, especially yellow blister disease, also cause significant losses. Under previous IPM/CRSP activities promising technologies for management of cowpea pests have been developed, validated, disseminated and adopted by a few farmers. This activity needs up-scaling to reach more farmers, by establishing field schools and interacting with other partners. Studies carried out in year 9 to determine economic injury levels (EIL) and action thresholds need to be continued in year 10 for confirmation of results at farm level. Likewise, studies on predators of cowpea insect pests need to be continued in year 10 and be integrated with IPM options. We need to better understand the efficacy of predators and parasitoids of cowpea pests to fully utilize these natural control agents in an IPM system. Better understanding of their biology and ecology may help us to enhance biological control in the Ugandan cowpea agroecosystem.

g. **Project output:** Recommendations on rational use of pesticides and non-chemical measures for managing cowpea pests identified, tested and disseminated. EILs established to guide pesticide usage, and knowledge of beneficial fauna and biorationals will be incorporated into the IPM packages. Pamphlets will be produced for disseminating research results. A broader cowpea germplasm base will be created for use by the cowpea-breeding program at SAARI.

**h.** **Project Impact**: (1) Reduced usage of pesticides. (2) Reduced cost of production and increased yield of cowpea in Uganda. (3) Incorporation of EILs on cowpea pest management (4) A broader cowpea germplasm base for both spinach and grain production in Uganda. (5) Enhancement of human capacity for research through student training (6) Stronger collaboration and new opportunities for networking among participating institutions.

**i.** **Progress to Date:**

- Validation of IPM technologies,has been completed, and the student has graduated. The proven IPM technologies are the ones being disseminated through the modified farmers schools which started in year 9 and they will be continued in year ten.
- EILs for cowpea thrips have been established and are being integrated in IPM packages. So far one seasons data has been collected in year 9 and will completed in year 10 A Student will graduate in 2003.
- A survey was conducted which provided a profile of beneficial arthropods in eastern Uganda agroecosystems and the performance of introduced cowpea lines were evaluated; these activities are ongoing for two additional season.
- Ten new cowpea varieties have been recommended for advanced testing by the cowpea breeding program at SAARI.

**j.** **Started**: September 2001

**k.** **Project Completion**: September 2003

**l.** **Projected Person-Months of Scientist Time per Year**: 3 months

**m.** **Budget for 2001/2002**: Makerere University – $14,060; Virginia Tech – $2,937; and Fort Valley University – $8,450; OSU – $3,780

### I.1.2. Integrated Management of Groundnut Insect Pests and Diseases

**a.** **Scientists:** E. Adipala; S. Kyamanywa, A. Kaaya - Makerere University; G. Luther and H. Warren - Virginia Tech, USA; A. Agona - NARO/KARI, G. Epieru - NARO/ SAARI; V. Odeke-DAO's Office, Kumi; R.B. Hammond and M. Erbaugh - Ohio State. Graduate (Mr. T. Munyuli) and Undergraduate Student - Makerere University

**Collaborators**: NARO-DFID (cost-sharing on MSc. student training, local networking for scaling-up)

**b.** **Status:** Continuing research with new activities.

**c.** **Objectives:** The broad goal is to develop integrated disease and pest management packages, including post-harvest packages, for groundnuts. Specific objectives are: (1) To validate and disseminate IPM packages; (2) To assess the effect of different insecticides on predators and parasitoids; (3) To determine economic injury levels and action threshold levels for leaf miners and thrips.

**d.** **Hypotheses:** (1) An IPM strategy, involving early planting, close spacing, rosette resistant varieties and minimum spray schedule (2-3 sprays of Dimethoate or 1-2 sprays of both Dimethoate and Dithane M45) will reduce the incidence of rosette and severity of Cercospora leaf spots diseases of groundnut; (2) Different insecticides exert the same level of mortality on predators and parasitoids; (3) There are predators and parasitoids that exert significant biological control pressure on some of the major insect pests of groundnuts in Ugandan; (4) Leaf miners, thrips and foot rot reduce groundnut yields in Uganda; (5) Suggested IPM packages are effective against rosette and Cercospora leaf spots and are economical.

**e.** **Description of Research Activity**:
This is an on going activity which is divided into three sub-activities: In all the trials, Rosette incidence and Cercospora (*Cercospora arachidicola*) severity will be assessed based on the scale used by Adipala *et al*. (1998) and the nine point model by Subrahmanyam *et al*. (1995), respectively. Leaf miner (*Aroarema modicella*) damage will be assessed based on a score scale of 1 - 3; where 1 equals <20% damage; 2 equals 20-50% damage; and 3 equals >50%. Foot rot (*Sclerotium rolfsii*) damage will be assessed based on the incidence of the disease per two center rows of each experimental unit. Thrips (*Thrips palmi* Karn, *Frankliniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus*) infestation will be assessed at a weekly interval starting at budding stage based on 20 flower buds /flower per experimental unit, depending on the crop growth stage. Aphid infestation will be assessed based on a scale of 1-5, where 1=no aphids, 2= >10 aphid/plant, 3= 10-50 aphids/plant, 4=>50-100 aphids per plant and 5= >100 aphids per plant.

<u>Validation and dissemination of IPM packages</u>. [E. Adipala; S. Kyamanywa - Makerere University; H. Warren-Virginia Tech, USA; G. Epieru-NARO/SAARI; R. Hammond and M. Erbaugh-Ohio State. IPM packages developed for groundnut pests and diseases and evaluated in year 9 will be evaluated by 3 groups of farmers (10 per group) in Kumi and Iganga districts. The treatments will include the farmers' practices (FP), calendar sprays (CS), and the improved practice (recommended by Mukankusi et al., 2001), i.e., early planting, close spacing (30 x 10 cm) and a minimum spray schedule of 2 Dimethoate. Joint farmer-scientist evaluations of the trial will continue. Additionally, cost-benefit analysis will be carried out to determine the profitability of the IPM packages.

<u>Impact of Predators and Parasitoids of Major Insect Pests on Groundnut</u>. [S. Kyamanywa; E. Adipala, - Makerere University; G. Luther - Virginia Tech, USA; G. Epieru-NARO/SAARI; R. Hammond - Ohio State; Theodore Munyuli - Makerere University].

<u>Assessment of the effect of different insecticides on major parasitoids and predators</u>**.**

Six commonly available insecticides at their recommended spray rates will be evaluated for their impact on mortality rates of groundnut parasitoids and predators. Parasitoids and predators populations will be monitored and major groundnut pests will be sampled and yield data recorded. The chemical treatment will also include a fungicide, Dithane M45, which will be used to control Cercospora leaf spot. The trial will be a completely randomized block design and replicated four times. Treatment plots will be 6m. by 6m. The study will be conducted at TVC at Kumi.

Effectiveness of Predators. Effectiveness of predation of Staphylinidae will be tested on *Aphis craccivora.* Depending on availability, ants may also be tested as predators of leafminer larvae. Cage experiments will be set up in the field with these predator and pest species combinations to determine predation rates. Cages will be infested with a known number of predator species along with individuals of the pest species to be tested. Counts of living prey and predators will be made daily for the first 5 days, henceforth every other day until all prey are killed and consumed. Each combination of predator species and pest species will be replicated 5 times. Unknown predator species will be sent to a specialist for identification. Predator populations will be sampled in the non-pesticide field described below in part to determine their abundance and diversity in this situation.

Determination of economic injury levels and action threshold levels for leaf miners, thrips and aphids. [Adipala; S. Kyamanywa - Makerere University; G. Epieru, R. Hammond; Undergraduate student - Makerere University]

Different chemical spray regimes will be used to vary population density and damage caused by leaf miners, thrips and aphids. Dimethoate will be the insecticide used in this trial, it will be applied at a rate of 1.25litre/hectare. Dithane M45 will be used to control Cercospora leaf spot. The treatments will include insecticides applied: once a week, twice a week, once every two weeks, and a control (no pesticides used). The trial will be a completely randomized block design and replicated four times. The study will be conducted at MUARIK and TVC at Kumi. Rosette incidence, leaf miner damage, aphid and thrips infestation will be assessed. At maturity, grain yields will be determined. Data collected will be subjected to Analysis of Variance (ANOVA). Gross Margin Rate of Return analysis will be used to determine the cost-benefit ratio of each spray schedule. Economic Injury levels of the two pests will then be computed and an insecticide spray schedule designed.

**f.** **Justification:** Groundnut rosette and cercospora leaf spots are major constraints to groundnut production, with farmers frequently recording total crop failures. Possible control measures include manipulation of plant density, early planting, use of resistant varieties and chemical sprays. As with other crops, disease and pest infestations on groundnut occur simultaneously. A better approach is to integrate control technologies in an IPM package in order to offer holistic crop protection for groundnuts. Currently recommended IPM packages have tended to be disease specific (usually directed at rosette or early leaf spot) and pest specific (directed at aphids), yet these pests and diseases often occur together.

Previous IPM CRSP activities have developed possible IPM packages for the control of these two diseases. However, these IPM packages need to be validated and disseminated to groundnut farmers. During the IPM CRSP studies other biotic constraints on groundout were recorded but their effect on yield has not been substantiated and at the same time no control measures have been designed for them. In this study, EILs and AT's for the commonly encountered constraints (leaf miners and thrips) will be determined and control measures designed. Biological control is usually recommended as the first line of defense in IPM. To implement bio-control we need to know the natural enemies in the system. Sub-activity (2) represents our attempt to utilize and maximize bio-control in the IPM system we are designing for groundnut in Uganda/ East Africa.

g. **Project Output**: Validated IPM packages for groundnut rosette and Cercospora leaf spots available to groundnut farmers. Other important pests and diseases of groundnut documented and control strategies identified. A list of predators and parasitoids of major insect pests that are most important in controlling of groundnut pests compiled and one Postgraduate/undergraduate student will be trained.

**h. Project Impact**: (1) Reduced usage of pesticides; (2) Development of an IPM package for groundnuts; (3) Reduced production costs and increased yield of groundnut in Uganda.

**i. Progress to Date**:

- Effects of time of planting, host resistance, plant spacing and pesticide application on groundnut rosette virus and Cercospora leaf spot have been studied.
- Fifty-seven groundnut genotypes from ICRSAT have been screened for resistance to groundnut rosette virus and Cercospora leaf spot, in two growing seasons.
- Efficacy of different pesticide in controlling major pests and disease of groundnuts have been studied during two previous cropping seasons.
- A survey of natural beneficial insect has been conducted during one growing season.
- One M.Sc student has been trained, graduated, and is now working for CIAT/Uganda.
- Four undergraduate students have been supported in their special project research (Mr. Dan Kabuye, G. Ishiagi, G. Kawube & Frank …………)

**j. Started:** September 2000

**k. Project Completion:** September 2003

**l. Projected Person-Months of Scientist Time per Year:** 3 months

**m. Budget for 2001/2002:** Makerere University – $ 22,530; Virginia Tech – $2,809; OSU – $3,906

**I.2. Important Cereal Crops associated with Farming Systems in Eastern Uganda.** This section focuses on continuing research activities to address major insect, disease and weed constraints on two important cereal staples, sorghum and maize.

**I.2.1. Integrated Pest and Disease Management Strategies for Maize In Uganda Year 10 Proposal**

**a. Scientists**: G. Bigirwa and Twaha Kalule, Sekamatte, B. NARO/NAARI; R.C. Pratt, P.E. Lipps and Ron Hammond, OARDC - OSU; S. Kyamanywa, E. Adipala, R. Edema - Makerere University; Graduate Students: R.G. Asea and S. Gordon, OARDC - OSU.

**Collaborators:** K. Pixley (CIMMYT); A. Mwang'ombe (University of Nairobi); J.B.J. van Rensburg (Grain Crops Institute, R.S.A.), Charles Omwega, ICIPE).

**b. Status:** Continuing Activities

**c. Overall Objectives:** (1) Enhance sustainability of maize production in mid- and high-altitude agro-ecosystems by improvement of host resistance to the leading foliar pathogens {Maize streak virus (MSV); *Exserohilum turcicum*, causal agent of Northern Leaf Blight (NLB); and *Cercospora zeae-maydis*, causal agent of gray leaf spot (GLS) disease and insect pests; stemborers (*Chilo partellus)* and termites. (2) Improve the ability to select host resistance to GLS by development of a laboratory based inoculation protocol (3) Enhance activity of biological agents to control termites and stemborers.

The specific objectives are: (1) Quantitative trait locus (QTL) mapping utilizing molecular-markers to enable marker-assisted selection (MAS) of quantitative resistance loci conferring resistance to MSV, NLB and GLS; (2) Development and testing of an inoculation technique involving *in vitro* cultured detached-leaves similar to that used for evaluating resistance to other cereal diseases (e.g. *Stagonospora* blotch of wheat) to determine if it will work for GLS screening; (3) Continue impact assessment study of *C. flavipes*; (4) Integrate application of ant baits and intercropping maize with *Desmodium*, soybean and cowpeas for termite and stemborer control.

**d. Hypotheses:** (1) Identification of significant QTLs for GLS resistance can be verified and shown to be heritable; (2) the QTlLs may result from the presence of major resistance genes so resistance gene analogs (RGAs) may be located in or near marker intervals that were significant for GLS; (3) Inconsistency of the earlier greenhouse inoculation protocol for GLS was probably due to the type of resistance being evaluated (partial resistance), to the long latent period required by the disease (14 to 18 days) and rapid growth of plants during early growth stages. We hypothesize that use of the *in vitro* assay will enable natural disease progress to occur; (4) The establishment and spread of an introduced parasitoid (*C. flavipes*) will reduce the infestation levels of the exotic stemborer (*C. partellus*) 5) Applying ant baits (fish/molasses) in maize-legume intercrops will lead to significantly lower termite and stemborer infestation levels than when either of them if used alone.

**e. Description of Research Activity:**

Approaches to increase availability of germplasm with durable resistance to multiple disease (gray leaf spot, northern leaf blight and maize streak virus). Selective genotyping was initially performed on the resistant and susceptible tails of the population derived from the cross Pa405 (susceptible) and the South African line VO613Y (resistant). We previously identified two quantitative trait loci (QTLs) for resistance, one on 1L (from Pa405) and another on 2L (from VO613Y). We will add additional SSR markers (approx. 30) and additional progeny lines (50-60) to ensure total genome coverage of 100+ markers. We will attempt to confirm the marker on chromosome 2L, and search for other resistance QTLs using the increased coverage and expanded population size. This is important to ensure the successful initiation of the expanded work on multiple disease resistance that will be accomplished through transfer of GLS QTLs identified in South African inbred VO613Y into CML202 (as described in biotech proposal).

Because the previous research suggested that resistance may be under major gene control, we will also include primers for resistance gene analogs (RGAs; a gift from Kansas State University) in our attempt to identify more markers in the expanded population. This will test the hypothesis that RGAs are located in or near marker intervals that were significant for resistance based on PLAA values. RFLP markers that may be significantly linked to resistance loci will be converted to cleaved amplified polymorphic sequence (CAPs) so that can be utilized as polymerase chain reaction based (PCR based) markers without the need for hybridization which requires radionucleotides.

In addition to PLAA data, lesion lengths and numbers will be assessed for selected resistant and susceptible lines and heritability estimates will be calculated by parent-offspring regression. Heritability estimates for the components of resistance mentioned above.

In vitro bioassay for screening maize germplasm for GLS resistance. Techniques have been developed to test for quantitative resistance in other host-pathogen systems that have long latent periods. We propose to evaluate *in vitro* detached-leaf techniques (Benediza et al., 1981; Kisha et al, 2001) used for evaluating resistance to other diseases e.g. *Stagonospora* blotch of wheat, in order to screen for resistance in maize to *C. zeae-maydis*. The techniques for the wheat protocol (Bendedikz et al, 1981; Kisha et al, 2001) will be modified and adapted to maize at OSU. Additionally, a potato leaf blight protocol (Toxopeus, 1954) will be modified and adapted by our cooperator at the University of Nairobi. Funding for the work in Nairobi has been solicited from the Rockefeller Foundation. Our objective will be to share results and cooperate on finding a practical procedure.

Briefly, leaves will be detached from green house grown plants at two different stages of development (V4 and V6-V7). They will then be surface sterilized and small sections will be excised and placed on wet blotting paper in petri dishes. Combinations of plant growth regulators e.g. anti-senescence compounds (cytokinins such as benzyladenine) and growth retardants (such as Flurprimidol, trade name Cutless) will be added to the medium at several different doses. The objective will be to find a treatment that slows the growth and or senescence of the plant material so that it can be preserved long enough for the pathogen to invade successfully. Progress of the fungal pathogen and the host tissue will be monitored under a dissecting microscope. Local isolates will be tested initially for their pathogenicity. Data obtained will be used to develop response curves. When a suitable procedure has been identified in a highly susceptible genotype, additional tests will be performed with susceptible, intermediate, and resistant genotypes to examine whether or not the detached-leaf bioassay can separate them. The leaf bioassay will then be correlated with field evaluations of the same genotypes in blind tests to be conducted in Ohio and Uganda.

Stemborer management.

Impact Assessment**.** Stemborer larvae will be collected on a monthly schedule during the long and short rainy seasons from release sites located in Iganga, Kumi, and Masindi districts to determine parasitoid establishment and evaluate impact of biological stemborers. Field sites included in the study will primarily include on-farm management plots linked to IPM/CRSP. Kumi district represent the mid-altitude semi-arid zones with a predominantly cereal (maize-sorghum-millet) cropping system surrounded by land rich in wild hosts. Masindi and Iganga are in the mid-altitude humid agro-ecologies in a predominatly maize-banana-coffee system. Data will be collected on: (1) Stemborer density/plant (2) percentage parasitism (3) stemborer species composition (4) parasitoid species composition (5) percentage parasitoid emergence (6) stemborer damage; stalk tunnel length, leaf damage, number of nodes damaged. The student will carry out studies on: (1) estimating mean borer densities in a small area (cohorts) (2) time specific mortality.

Study on spread**.** The efficiency of a released natural enemy depends on the searching capacity and rate of dispersal (spread). These to a large extent indicate whether the natural enemy would be fully established or not. The first stage in impact assessment therefore involves the determination of the spread and establishment of the natural enemy. Sampling outside release sites in Kumi, Iganga and Masindi districts will be carried out to determine the extent to which the parasitoid has colonized new areas from point of release. Starting from the release site, systematic samples will be taken in different directions (axes) 2-3 times a season. To obtain a population estimate of *C. partellus* and the natural enemies, the field will be randomly sampled. Whenever *C. flavipes* is observed in the field, sampling will continue on this axis for another few kilometers in order to establish the spread. Data will be taken on the stemborer and natural enemy complex.

Termite management. Previous work on termites using fish based bait showed an increase of 84% ant activity and 54% termite reduction. In year 10 it is being proposed to demonstrate the technology on farmers' fields in two districts, Masindi and Iganga. A participatory approach will be used where farmers' groups will discuss the technology and identify farmers who will participate in the demonstration. Fifteen demonstrations will be established in each district. A modified farmer field school approach will be used, in which farmers will be involved in activities like; planting, mixing of the fish bait, its application and monitoring the damage. The treatments in the demonstration will include; plots with and without fish bait and will measure 15 x 20 meters separated by 2m alley. Farmers will serve as replications. The fish bait will be applied at a rate of 500 grams per plot at 4 and 9 weeks after emergence. Date will be taken termite damage, ant activity and yield. The incidence of predatory ants will be assessed by inspecting the forty plants sampled for termite damage for presence of ant nests within a 25 cm radius around the plant stem bases. An ant- nesting index expressed as the number of maize plants out of 40 with ants nests will be calculated.

**f. Justification:**

(1) Gray leaf spot (*Cercospora zeae-maydis*), maize streak virus, and northern leaf blight (*Exserohilum turcicum*) are the three major maize diseases in Uganda. Considerable efforts are being made by the national research programs (NARO and Makerere) in collaboration with scientists from other institutions like OARDC-USA and CIMMYT to address these diseases. Several control and management options have been tried but host resistance is the most cost effective for the majority of farmers in the country. Conventional breeding takes long and is not as precise as new biotech tools that are readily available in advanced laboratories of OARDC-USA. These new tools will be employed to help in the selection and identification of sources of resistance for use in improving the elite materials in Uganda. Stem-borer parasitoids appear to be having an impact on stem-borer populations. Verification of this would support the initial efforts to examine the feasibility of releasing an additional parasitoid species

(2) The introduction and establishment of *C. flavipes* represents a case of biological control that should have a sustainable impact on the reduction of stemborer injury. Previous studies indicate that *C. flavipes* has had good establishment in Kumi and Iganga districts but very poor establishment in Masindi (<10%). These studies also show a strong correlation between grasses (cereals + wild hosts) and parasitism especially in Kumi. What are not clear are the observed differences in establishment of the parasitoid in the release sites. Thus, it is important to understand the factors that account for the differences in establishment and spread of *C. flavipes* across locations and its effect on the target pest, the stemborer complex and the associated parasitoid complex. Such knowledge would be used in strengthening and sustaining its impact on stemborer populations.

(3) Termite damage is another limiting factor in maize production. Recent studies in Uganda have indicated that both intercropping and application of fish bones and molasses reduce termite attack on maize by enhancing the activity of indigenous predatory ants (Sekamatte, 2001). Species of the genera *Myrmicaria* and *Lepisiota* were the dominant ant predators recorded. These results need to evaluated and disseminated to farmers.

(4) We are concerned with publishing the results of the greenhouse inoculation protocol because it has been difficult to repeat. It is especially difficult to quantify the amount of disease on the immature plants. We were hoping the technique would work better, but we did not seem to get the level of disease needed to easily separate germplasm with known reactions in the field. Inconsistency may be due to the type of resistance being

evaluated (partial resistance), to the long latent period required by the disease (14 to 18 days) and rapid growth of plants during early growth stages. Regardless, it is not an easy task to perform and it is important that pathologists will be satisfied with the technique.

We feel we may need to resort to a more precise type of bioassay. Techniques have been developed to test for quantitative resistance in other host-pathogen system that have long latent periods. We feel we should try some of these techniques to see if they work for *C. zeae-maydis*. Basically the technique involves an in vitro detached-leaf assay used for evaluating resistance to other cereal diseases (Stagonospora blotch of wheat). This would eliminate the problem with maintaining proper environmental conditions in the greenhouse and the rapid growth of young plants. The most difficult part will be keeping leaf tissues alive in culture for 14 or more days.

g. **Relationship to other activities:** (1) The proposed work will complement the on-going studies on identifying farming components responsible for high GLS incidence and development, identification of sources of resistance to 3 main foliar diseases, and effect of stover on GLS development. It will also make a follow-up to IPM CRSP funded activities so that the farmers come to know the diseases affecting maize production and start to take steps to contain them. (2) This study follows previous studies on IPM/CRSP studies on stemborer/parasitoid interactions and release of the braconid parasitoid, *C. flavipes*. The study will focus on field sites carrying out IPM/CRSP activities and other farmers in the vicinity. (3) The effects of fish baits, broadcast or buried with a few dry stalks of maize, in a maize crop, termite activity and damage have been studied. (4) The proposed work will compliment other management options being tried out e.g. crop rotation with non-cereals, increased soil fertility and host resistance.

h. **Progress to date:**

(1) Graduate student (S. Gordon) completed the research and analysis on the initial QTL mapping effort using selective genotyping. Two resistance QTLs are associated with resistance and they appear to be different than those reported in the US. (2) A manuscript describing the above results has been submitted to the Crop Science journal. (3) The work described above using the expanded population and additional markers has been initiated. (4) Most resistant segregating lines have been planted in the greenhouse for crossing with CIMMYT lines CML 202 and CML 390. (5) Graduate student (Asea Godfrey has successfully completed first quarter of study at OSU). (6) The manuscript on epidemiology of GLS in tropical environment has been published in the Annals of Applied Biology (G. Asea, , G. Bigirwa, E. Adipala, S.A.P. Owera, R.C. Pratt and P.E. Lipps. 2002. Effect of *Cercospora zeae-maydis* infested maize residue on progress and spread of grey leaf spot of maize in Central Uganda. Annals of Applied Biology 140:177-185. (7) A paper was entitled: The effect of farming systems on the development of GLS epidemics in two districts of contrasting incidence, was presented during the Seventh East and Southern Africa Maize Regional Conference held in Nairobi, February 2002: The authors are Bigirwa, G., Pratt, R.C., Adipala, E. and Lipps, P.E.

(1) Evidence of parasitoid establishment has been documented in some areas with parasitism rates of up to 30%. (2) Recovery of the parasitoid in non-release areas

demonstrates the ability of the parasitoid to colonise new areas. (3) The high emergence rate of adult parasitoids indicates that there are probably no negative cultivar-mediated effects on parasitoid survival and development. (4) 2 M. Sc. level Makerere graduate students have began their studies on the project and are working closely with NARO scientists. However, percent parasitism was highly variable over locations with parasitism levels of *C. flavipes* less than 10% in some locations. The challenge is to try and explain the underlying factors influencing the observed differences in establishment of the parasitoid across locations.

One season's data has been collected and analysed. Results of analysis and field observation on treatment impact on stemborers indicate high potential of the two techniques to control both termites and stemborers.

**i.** **Projected Outputs:** (1) resistance factors and their association with components of resistance identified; (2) SSR molecular markers for MAS selection identified. (3) An alternative strategy for termite and stemborer management developed. (4) A rapid screening tool to allow inoculation of plants with GLS at any time thus improving the efficiency of host resistance selection for breeders (5) Increased, sustainable maize yields.

**j.** **Projected Impacts:** (1) reduction in maize losses and increased production; (2) a shortened process for identifying sources of resistance, selection and testing; (3) enhanced maize resistance to many diseases; (4) sources of resistance for utilization in Uganda and USA not only identified – but utilized.

**k.** **Projected Start Date:** September 2002

**l.** **Project Completion:** September 2003

**l.** **Project Person-Month of scientist time per year:** 3 months

**n**. **Budget:** NARO – $13,805; OSU – $21,672

### I.2.2. Development of options for *Striga* management for small holder sorghum farmers

**a.** **Scientists:** J.R.Olupot - MAAIF; B. Sekamatte - SAARI/NARO; J. Oryokot - NAADS; Herman Warren and Brhane Gebrekidan - Virginia Tech

**Collaborating Institutions :** ICIPE and NAARI.

**b.** **Status:** Continuing activity with some modification in methodology.

**c.** **Objectives:** (1) To evaluate the effect of intercropping sorghum and silver leaf desmodium (*Desmodium uncinutum*) in the management of *Striga*. (2) To identify 2,4-D and 2,4-DB herbicides tolerant sorghum genotypes and evaluate the efficacy of herbicide seed coating in *Striga* management. (3) To develop an effective and rational crop rotation system for *Striga* management in eastern Uganda. (4) To determine the effect of integrating intercropping, seed coating and fertilizer use for the management of *Striga*

**d. Hypothesis:** (1) Inter-cropping sorghum and silver leaf desmodium affects *Striga* infestation in sorghum. (2) Seed coating sorghum seeds with 2,4-D and 2,4-DB herbicides reduces striga infestation in sorghum. (3) There are differences in *Striga* infestation under continuous sorghum cropping and the proposed crop rotation system. (4) There are differences in sorghum yields between the integrated management strategy and single practice management options.

**e. Description of research activity:**

Effect of intercropping sorghum with Desmodium on Striga infestation. A field trial will be carried out in farmers' fields at five sites in Kumi district to evaluate the efficacy of intercropping Seredo with silver leaf desmodium in *Striga* management. *Desmodium* will be compared with other known trap crops i.e. Cowpea, Bambara nuts and *Celosia argentia*. *Desmodium* will be left in the field for two seasons and plots will be permanently marked in order to realise its full effect. This is because the rate of growth of *Desmodium* has been observed to be slow. The planting arrangements will include: 1:1, 2:1, 2:2 and 1:2. Application of a recommended fertilizer rate will be included as a control. Data to be collected will include *Striga* emergence, *Striga* soil seed bank, crop growth parameters, sorghum yield, total *Desmodium* biomass and stalk borer damage. Statistical analysis will be carried out using Genstat statistical package.

Screening sorghum germplasm for tolerance to 2,4-D and 2,4-DB. Sorghum germplasm that have shown tolerance to 2,4-D and 2,4-DB seed coating will be taken for field evaluation. This will be an on-farm trial conducted in Kumi district at five hot spot *Striga* sites, to evaluate the efficacy of coating sorghum seed with 2,4-D and 2,4-DB on *Striga* control.A lower herbicide concentration of 0.05% a.i for each of the herbicides will be used. Data to be collected will include; *Striga* seed germination and emergence, crop growth parameters and crop yield. Statistical analysis will be carried out using Genstat statistical package.

Effect of cotton/sorghum/cowpea rotation system on *Striga* infestation. This is an ongoing study which was started on farmers field initially identified as striga hot spot in Kumi District. Two cropping regimes were imposed; one to receive a cotton/sorghum/cowpea rotation treatment and the other continuously cropped with sorghum. This is replicated five times. The cropping scheme is as follows: (1) Cotton/sorghum/cowpea: 1$^{st}$ rains 1997 (cotton), 1$^{st}$ rains 1998 (sorghum), 2$^{nd}$ rains 1998 (cowpea), 1$^{st}$ rains 1999 (cotton), 1$^{st}$ rains 2000 (sorghum), 2$^{nd}$ rains 2000 (cowpea), 1$^{st}$ rains 2001 (sorghum), 2$^{nd}$ rains 2001 (cotton), 1$^{st}$ 2002 (sorghum). (2) Continuous sorghum cropping: under sorghum all seasons up to 1$^{st}$ rains 2002. Recommended fertilizer rates, varieties and cultural practices will be used in all plots. The recommended fertilizer rate is to provide $80kgNha^{-1}$. The recently recommended sorghum variety for the area, Seredo will be planted. The recommended varieties for cotton and cowpea for the Kumi area will also be planted. Appropriate cultural practices for the management of these crops will be followed, including planting dates and plant densities. The data to be collected will include *Striga* plant count after emergence, *Striga* seed bank in the soil, both at the start of the trial and at the end of each season in both the rotation and continuous sorghum plots. In each plot, soil sampling will be carried out along the plot length. A five-centimeter diameter soil auger will be used to obtain soil cores to the depth of the plough layer (approx. 10cm). A total of twenty soil cores will be obtained from each field and composted to give a single sample from which *Striga* seed bank will be determined. Soil and socio-economic analysis will be performed and the impact on *Striga* interpreted on that basis.

<u>Integration of intercropping, seed coating and fertilizer use in management of *Striga*.</u> An on-farm study will be conducted at five *Striga* hot-spots in Bukedea; two sites with UNFA Kachede farmers and three sites with BUWOSA farmers. The trial will consist of the following options; (1) the integrated *Striga* management practice identified from an earlier study; (2) intercropping seredo sorghum with silver leaf desmodium and (3) seed coating with herbicide and cultural practice. Data to be collected will include emerged *Striga* plants, *Striga* soil seed bank, crop growth parameters, crop yield and person-hours (days) for weed control. In each plot, soil sampling will be carried as indicated above in section 1-3. Available soil nitrogen will also be determined. Rainfall data will be collected using portable rain gauges for interpretation of the data. Statistical analysis will be carried out using SigmaStat statistical package. A paired t-test will be used to compare farmer practice and the integrated *Striga* management strategy.

f. **Justification:** The integrated management strategy for *Striga* developed is suitable for farmers when the yields are good and can compensate for low price of sorghum and the cost of fertilizer. Under either poor yields due to drought or low sorghum price, the cost of fertilizer may not be recouped. Under these conditions, viable options for the management of *Striga* that provide farmers with choice under different sorghum production environments are needed. The West African site in Mali has been evaluating seed coating of sorghum seed with 2,4-D and 2,4-DB as a possible component for management of Striga. Both 2,4-D and 2,4-DB have been tried on a limited number of sorghum genotypes under Ugandan conditions. Preliminary results of one season indicate promise in suppressing *Striga* emergence but had negative impact on sorghum performance at 0.1% concentration of the herbicides. The new approach is to lower the herbicide concentration to 0.05% and screen more sorghum germplasm available in the country. Elsewhere (ICIPE), *Desmodium* has been shown to reduce *Striga* infestation when inter-cropped with maize as well as reducing stalk borer infestation. This effect of Desmodium needs to be evaluated on sorghum in Uganda. Preliminary results have indicated that Desmodium has potential to reduce *Striga* infestation and improve on sorghum yield. These findings need to be re-validated in order to get more accurate and reliable data. In addition, the need to conduct a socio-economic analysis of these findings requires four (4) season's data.

g. **Relationship to other CRSP activities:** This work is related to other CRSP activities that have been conducted under controlled conditions at Virginia Tech to develop novel approaches to *Striga* management. It is also related to the *Striga* management studies being carried out in Mali, West Africa. All these studies are aimed at developing management options for *Striga* management that are suitable for small-scale farmers.

**h.** **Projected output:** Novel management options for *Striga* management in Ugandan conditions.

**i.** **Projected impacts:** (1) Reduced incidence of *Striga*; (2) High sorghum yield; (3) Depleted *Striga* seed bank; (4) Higher income for small-scale sorghum farmers.

**j.** **Progress to date:** The earlier part of this work involving development of an integrated management strategy for *Striga* has been completed and has been written as part of the student's Msc. Work and presented in International Weed Science Conference. The crop rotation study will be entering the seventh season on the site. Preliminary results on intercropping and seed coating have shown promise for *Striga* management in Uganda.

**k.** **Start-date:** 1998

**l.** **Projected completion:** September 2003

**m.** **Projected person-Months of Scientist Time per year:** 3 person months of scientists time per year. A full time student involved with the project is now at the final stages of completion.

**n.** **Budget:** Makerere/Uganda – $ 5,458; Virginia Tech – $6,002

**II.1.** **Development of IPM strategies for High Value Horticultural Crops.** Activities will continue in Year 10 on developing IPM strategies for tomato. Activities on potato have been concluded and USA and Ugandan collaborators have either retired or been reassigned.

### II.1.1 Development of IPM Technologies for Tomato Production in Central Uganda

**a.** **Scientists Names and Institutional Affiliations**: Akemo M.C., Hakiza J.J. - KARI; Kyamanywa S., Adipala Ekwamu, M. Magambo, A. Kaaya - Makerere University; M. Erbaugh, R. Hammond and P. Grewal - Ohio State University; A. Alumai Graduate Research Assistant funded by OSU.

**b.** **Status**: Continuing activity.

**c.** **Overall Objectives**: To reduce the use of pesticides on tomatoes. The specific objectives are: (1) To develop alternative interventions for controlling priority diseases and pests of tomatoes; (2) To identify bacterial wilt resistant indigenous Solanaceae rootstocks for tomato grafting; (3) To establish the levels of dithiocarbamates in tomatoes and their effects on shelf-life (4) To develop biological control alternatives involving entomopathogenic nematodes to manage thrips and African bollworm.

**d.** **Hypothesis**: (1a) Improved tomato varieties and cultural practices will reduce incidence and severity of bacterial wilt, early and late blight, and insect pests (1b) The frequency of pesticide application can be reduced without yield loss. (2) Use of grafting and rootstocks resistant to soil-borne diseases will reduce disease incidence. (3) There are high levels of pesticides residues on tomatoes sold in Ugandan markets. (4) Entomopathogenic nematodes are effective alternatives to chemical pesticides in the management of thrips and African bollworm on tomatoes in Uganda.

**e.** **Description of Research Activity (approach):**

Evaluation of selected tomato lines and management practices on incidence of *Phytophthora infestans, Ralstonia solanacearum,* and insect pests on tomatoes. (Akemo M.C, J.J. Hakiza, H. Warren, M. Olanya). After the 2002a season on station, the 3 best performing lines and the 3 management practices which combine the best disease and insect pest control with economic yields will be taken and tested on-farm for 2 seasons. This will be done with 2 farmers' groups at 2 different tomato-producing areas in Wakiso District. A check trial will be run on-station at KARI at the same time. The design will be a split block, with management practices as the main plots, replicated 3 times. The tomato treatments will be replicated within the management practices. The locally grown varieties will be used as controls, making 4 tomato treatments in total. Data will be collected on diseases (*Phytophthora infestans, Ralstonia solanacearum*) and insect pest (*Thrips tabaci, Myzus persicae, Helicovepa armigera, Bemisia tabaci*) incidence and severity at biweekly intervals. The trials will also serve as demonstration sites from which the farmers will select the best option.

Field performance of tomatoes grafted on selected *Solanum* sp rootstock. (Magambo M.J.S., Kasenge V., Kyamanywa S.**)**. Rootstocks of *Solanum indicum* subsp. Distichum, *S. macrocarpon*, and *S. camphylocanthum* will be grown in the field in a randomized complete block design with 4 replications. Thereafter tomato scions of local popular varieties will be grafted on to the rootstocks at the right stage. Data will be collected on general growth characteristics of the grafted plants, disease and yield. , and economic implications will be assessed. The data will be statistically analyzed. The experiment will be carried out on selected farmers' plots in Wakiso district.

Determination of dithiocarbamate fungicide residues in tomato fruits. (Kaaya Archileo). Tomato samples of 1kg each will be purchased from Nakasero and St. Balikudembe markets. Five samples will be obtained from each market and their residues determined. Another batch of 10 samples of 20 fruits each will be purchased from farmers and their shelf-life attributes (color, firmness, pH, TSS, acidity, and microbial infection) evaluated using data obtained in year 9 on the dithiocarbamate levels applied by farmers. All studies shall be done in the Department of Food Science and Technology, Makerere University.

Evaluation of three entomopathogenic nematode strains for the control of thrips and African bollworm on tomatoes (Alfred Alumai**)**. Two trials will be conducted at the Kwanda Agricultural Research Institute (KARI) on tomatoes. One trial will evaluate the potential of nematodes to control thrips and the other will be for the African bollworm. There will be 5 treatments in each trial involving three nematode species, a standard insecticide treatment, and an untreated control. Plot size will be 2 x 2 m and a complete randomized design with 5 replications will be used. The treatments will be applied as curatives with sprinkling cans late in the evening. The nematode species will be *Heterorhabditis bacteriophora* (Ohio strain), *H. zealandica* and *Steinernema carpocapsae*. Data on insect mortality shall be recorded two weeks after application. Plant damage and yield will be assessed before harvest. These two experiments will be repeated during two growing seasons.

Capacity building. A student is being trained in entomology at MSc level at MUK.

**f.** **Justification:** Tomato blights and Bacterial wilt have been ranked both by NARO and farmers as priority diseases on tomatoes in Uganda. There is also extensive damaged caused by insect pests such as thrips (*Thrips tabaci*), African bollworm (*Helicoverpa armygera*), and. vectors of tomato viruses. To control these problem farmers rely on extensive use of pesticides. Farmers, however, do not use pesticides correctly, resulting in undesirable residues on the harvested tomato fruits. The levels of these residues are not known. There is need to reduce pesticide use studying the effect of different cultural methods on Late blight will help reduce pesticide applications against this disease and reduce crop loses. Similarly resistant varieties and grafting are 2 methods that can be employed to avoid crop loss from the soil-borne bacterial wilt.

**g.** **Relationship to other CRSP activities at the site:** The proposed research builds upon on-station studies at KARI and MUARIK that have been examining alternative methods of controlling tomato diseases and insect pests. It also follows upon studies initiated on dithiocarbamate residues on tomatoes.

**h.** **Progress to date:** 1½ year's testing the effect of 7 management practices and 13 bacterial wilt resistant lines introduced from AVRDC Taiwan have been carried out. Six *Solanum* rootstock species were tested for compatibility with tomato scions and resistance to *Ralstonia solanacearum*. Three management practices are reducing severity of late blight infection. Out of the 13 introductions only 3 have had some plants wilting. All the 6 rootstocks were compatible with tomato scions. However, only *Solanum macrocarpon, S. indicum* subsp *distichum,* and *S. camphylocanthum* were compatible and resistant to Bacterial wilt. On pesticide residues samples were obtained from farmers and the markets at Gayaza, Kasangati, and Kalerwe. Information on levels and frequency of Dithane M45 application was obtained.

**i.** **Projected outputs**: (1) Bacterial wilt resistant/tolerant tomato cultivars identified. (2) Alternative disease and insect pest management practices developed. (3) Information on the levels of dithiocarbamate residues in tomatoes and the role of the different levels of DM45 in prolonging the shelf life of tomatoes shall be established. (4) Student trained to MSc level. (5) Publications.

**j.** **Projected impact:** (1) Losses due to tomato diseases and pests reduced. (2) Farmer's incomes increased. (3) Reduction in pesticide use. (4) Awareness by consumers on the safety hazards of tomatoes in Uganda and the role of DM45 as a post-harvest fungicide. (5) Capacity to handle horticultural entomology problems increased.

**k.** **Project start**: September 2002

**l.** **Project end**: September 2003

**m.** **Projected Person-months of Scientisits' Time per year**: 12 months

**n.** **Budget:** Makerere/NARO – $15,147; OSU – $7,560.

## III. Post-harvest

### III.1.1 Moulds and Mycotoxins in Maize and Groundnuts in Uganda

**a.** **Scientists**: A. N. Kaaya, E. Adipala, S. Kyamanywa – Makerere University; H. Warren – Virginia Tech; A. Agona – KARI and G. Bigirwa – NAARI, G. Sseruwu-Makerere University

**Collaborators:** Rockefeller Foundation

**b.** **Status**: Continuing activity

**c.** **Overall objective**: To identify on-farm practices/factors which influence mould incidence and mycotoxin contamination of maize and groundnuts. **The specific Objectives for Year 10**: (1) To compile harvesting, drying, shelling and storage regimes of maize and groundnuts at farm and market levels as they relate to moulds and mycotoxin contamination of these commodities; (2) To study changes in moisture content, insect damage, germination potential, mould and mycotoxin contamination of solarised and non-solarised maize kernels; (3) To validate recommended improved drying methods on moulds and mycotoxins in maize; (4) To establish temperature and exposure periods that eliminate moulds and prevent subsequent mycotoxin production in grains; (5) To train a graduate student at PhD level.

**d.** **Hypotheses**: (1) Prolonged exposure of maize kernels to solarisation temperatures significantly affect their moisture content, insect damage, germination potential, and subsequently mould and mycotoxin contamination. (2) Drying maize in biomass dryers significantly reduce mould infection. (3) Oven method can be used to establish temperature and exposure times to eliminate moulds from grains.

**e.** **Research Activity:** (1) The Ph.D. student has already registered at Makerere University. The student will carry out coursework at Virginia Tech beginning August 2002 for one year and thereafter return to Uganda to continue with research and write a dissertation. IPM CRSP shall maintain the student at Virginia Tech and finance research in Uganda.

Makerere University shall pay for tuition while the student is in Uganda. Data on harvesting, drying, shelling and storage regimes of maize and groundnuts at farm and market levels shall be compiled, analyzed and paper/report written while at Virginia. These data are available from the previous studies. Thirty maize samples dried in the field shall be collected from 15 farmers from Mayuge district 2 samples per farmer. The samples shall be subjected to solarisation for 3, 4, 5 and 6 hours and stored in PE bags. Moisture content, insect damage, germination potential, moulds and mycotixins shall be analyzed before and after solarisation. The solarised samples shall be sent to USA so that they can be analysed by the student while there. The biomass dryer shall be used to establish the effects of improved drying methods on destroying moulds. The oven methods shall be used to dry maize samples in order to establish the optimum temperature and period for the elimination of moulds. (2) The RF will fund all research activities of the MSc. student who will look at fungal microflora responsible for ear rots in maize in highlands and mid-altitudes of Uganda; maize variety evaluation for ear rots resistance, and identifying suitable inoculation method for ear rots.

**f.** **Justification:** During Year 9 it was observed that information on harvesting, drying, shelling and storage regimes is needed by farmers, traders and exporters to control mycotoxin contamination in maize and groundnuts. Solarisation for 3 hours was found to be effective in reducing moisture content and insect infestation but not moulds and germination potential. There is the need to increase the exposure time and also study the virulence of the moulds and their ability to produce mycotoxins during storage. Biomass drying is a method already recommended for drying maize and has been adopted by some farmers in Kapchorwa. This method needs to be validated in terms of mould and mycotoxin control. Oven drying gives consistent and exact temperatures that can easily be obtained to destroy moulds. This information is very important for recommending drying regimes of grains especially those intended for export. There are some funds budgeted for the student to go to Virginia Tech for course work during Year 9. Ear rots are becoming of economic importance and this has led to rejection of grain desired for export. Some commercial varieties are succumbing to the disease hence the need to identify sources of resistance

**g.** **Relationship to other CRSP activities at the site:** The proposed study is related to on-going work on moulds and mycotoxin incidence in maize and groundnut and also to post harvest studies related to storage and insect infestation control.

**h.** **Progress to-date:** PhD student has already registered at Makerere University and is in the process of going for coursework at Virginia Tech. Moisture content, insect damage, germination potential and moulds have been determined in maize in relation to harvesting, drying, shelling and storage practices in Mayuge district. Solarisation of maize kernels for three hours was carried out and it was found to have no significant effects on moulds and germination potential, but significantly reduced moisture content and killed all insect pests. Maize stored by traders for 5-6 months had the highest insect damage and mould incidence. Except kernels obtained from the field, the rest had poor germination potential and this was attributed to poor methods of drying, beating during shelling and insect damage.

i. **Projected output:** Relevant technologies required to control and monitor moulds and mycotoxin contamination during handling and storage of grains shall be established.

j. **Projected Impacts:** (1). Control of moulds and mycotoxin contamination of maize and groundnuts in Uganda (2) Increased export potential of maize and groundnuts (3) Improved consumer safety of grains.

k. **Projected start:** October 1, 2002

l. **Projected completion:** September 30, 2003

m. **Projected Person-Months of scientists time per year:** 3 months

n. **Budget:** Makerere – $8,806; Virginia Tech – $14,875

### III.2.1. Effect of Splitting on Biology of *C. maculatus,* Quality Attributes and Marketability of Cowpea Seeds

a. **Scientists:** J. A. Agona, S. Kyamanywa, A. Kaaya, H. Warren, J. Bonabana, V. Kasenge, W. Ekere, M. Erbaugh and D. Taylor

b. **Status:** Continuing

c. **Overall Objective**: To promote processing, storage, utilization and marketability of split cowpeas. **Specific objectives**: (1) To study the biology and population dynamics of *C. maculatus* on split cowpea; (2) To determine the effect of splitting on quality attributes (cooking time, culinary and organoleptic and mould infection).

d. **Hypotheses:** (1) Development of *C. maculatus* is affected by splitting cowpea seeds. (2) Quality attributes of cowpeas are improved by splitting of seeds.

e. **Description of research activity:** Laboratory studies will be conducted to determine the establishment and population build up of *C. maculatus* on split cowpeas. The generation time, number, sex, hatchability, longevity, size and fecundity of emergent adults will be determined. The effect of splitting cowpea seeds on mold infestation, cooking time, palatability and color will also be studied. Panel tests will be conducted monthly on split cowpea seed stored for up to 6 months to determine palatability. Scores will be based on Hedonic scale of 1-5.

f. **Justification**: Previous IPM CRSP work has demonstrated that splitting of cowpea seeds prior to storage caused significant reduction of bruchid damage as well as adult emergent numbers suggesting that it could be a good component of IPM for storage bruchids. However the effect of splitting on biology of *C. maculatus*, culinary and organoleptic qualities as well as market acceptability and opportunities are not well understood. A study on splitting cowpeas, is therefore necessary to fill in these knowledge gaps.

**g.** **Relationship to other CRSP activities**: This activity is related to other IPM CRSP Research on post-harvest management of cowpea in Uganda.

**h**. **Progress to**-date: New activity

**i.** **Projected Outputs:** (1) Knowledge on the biology of *C. maculatus* on split cowpeas; (2) Proocessing, storage, utilization and marketability of split cowpeas.

**j.** **Projected impacts:** Livelihoods of farmers in terms of food security, good nutrition and raised incomes improved.

**k.** **Project Start date:** September 2002

**l.** **Projected Completion:** October 1, 2003

**m.** **Projected Person Months of scientists time per year:** 12 man- months

**n.** **Budget:** Makerere/NARO – $3,850; Virginia Tech/OSU (see IV.1).

## IV. Socioeconomic Assessment of IPM CRSP Technology Development, IPM and GIS Dissemination and Symposium Proceedings Support

### IV.1. Socioeconomic Assessment of IPM CRSP Technology Development Activities in Uganda

**a.** Scientist(s) Names and Institutional Affiliations: *Principal Investigators:* V. Kasenge, W. Ekere, J. Bonabana,[1] B. Mugonola,[2] P. Kibwika, M. Amujal[3] – Makerere University; V. Odeke, E. Mwanja – Uganda Extension Crop Protection Specialists; Daniel B. Taylor – Virginia Tech; J.M. Erbaugh – Ohio State. *Collaborating Scientists*: S. Kyamanywa, A. Kaaya, C. Akemo, E. Adipala – Makerere University; G. Bigirwa, B. Sekamatte, J. Olupot, A. Agona - NARO; H. Warren, G. Luther – Virginia Tech.

**b.** **Status:** New and Continuing[4] Activities

**c.** **Overall Objective(s):** The overall purpose of this research is to assess the economic impacts of IPM CRSP activities in Uganda at: the level of the individual production

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[1] She began her M.S. program at Virginia Tech in August 2000.
[2] He began his postgraduate studies at Makerere University in September of 2000. Upon completion of his M.S. thesis in September 2002, he will be hired as a research assistant to work on IPM CRSP economic analyses.
[3] She began her postgraduate studies at Makerere University in September of 2001.
[4] Given the cropping seasons in Uganda, and the IPM CRSP's fiscal year, many of the analyses for the second cropping season cannot be completed until after the start of the new IPM CRSP fiscal year.

activity, farm, region, nation, and beyond as appropriate.[5] Resource limitations prevent comprehensive evaluation of all technologies at all levels. We will attempt to evaluate all promising technologies at the individual production activity level, while only a few technologies will be subjected to a more comprehensive analysis. **Objectives for the coming year:** (1) to evaluate the farm level economics impacts of IPM packages on maize, groundnuts and cowpeas; (2) to assess factors influencing the adoption of IPM CRSP packages for groundnuts, sorghum and cowpeas; (3) to analyze the tomato marketing system including assessing the effect of visible pesticide residue on sales of tomatoes; and (4) to evaluate consumer acceptability of split cowpeas in the market.

d. **Hypotheses:** Adoption of IPM CRSP technologies is inversely related to farmers' age. Adoption is directly related to farm size (or per capita farm size), income and education level. Women are less likely to adopt IPM technologies than men. IPM CRSP technologies are profitable.

**e. Description of Research Activity (approach):**

New Activity A production function will be estimated for Maize production in eastern Uganda. Optimal input use will be determined, and the influence of risk on input use will be assessed (B. Mugonola,[6] V. Kasenge, G. Bigirwa). In an extension of the pilot marketing study conducted last year, an in depth marking study of peri-urban tomato production will be conducted. Of continued interest is the effect of visible pesticide residue on tomato sales. Some say it enhances their sales, as some people perceive them to be of higher quality with residue – others say that the residue decreases sales because consumers are concerned about the health impacts of pesticides. Vendors, suppliers, market overseers and consumers will be interviewed. The interviews will be conducted in four seasons, central and satellite markets in each of the 5 divisions of Kampala in both big and small markets in each division (V. Kasenge, B. Mugonola, A. Kaaya). Samples of tomatoes have been collected for pesticide residue testing, and the tests will be conducted shortly. Splitting cowpeas before storage is a promising technique for post harvest *Bruchid* control. The acceptability of split cowpeas in the market will be assessed. Sales of the split cowpeas in markets in Kumi will be evaluated with both loose and bagged cowpeas compared to whole loose cowpeas (J. Bonabana, B. Mugonola, A. Kaaya, A. Agona, E. Adipala). The economic impact of the use of fish baits and intercrops to attract predatory ants in controlling termites in Maize will be evaluated (W. Ekere, B. Mugonola, B. Sekamatte, S. Kyamanywa).

Continuing Activity. A survey will be conducted in Kumi District to assess factors influencing the widespread adoption of pest management packages generated by the CRSP for sorghum, groundnuts and cowpeas. A random sample of both men and women farmers will be surveyed (J. Bonabana, [7] D. Taylor, M. Erbaugh, V. Odeke). In addition the influence of farmer field schools on IPM cowpea technology adoption will be

[5] Currently, with the possible exception of some seeds and some planting materials the free market, without government intervention, provides inputs.
[6] B. Mugonola's M.S. thesis. Following completion of this thesis, he will be hired as a research project for the next year of the project.
[7] Her M.S. thesis.

assessed (M. Erbaugh, P. Kibwika, E. Mwanja).[8] The assessment of the cost effectiveness of management practices for pest and disease control on cowpeas in the field, and their implications for post harvest storage will continue (B. Mugonola, A. Agona, E. Adipala, S. Kyamanywa). Striga control treatments on sorghum including the seed treatments and intercropping will continue to be assessed with partial budgeting (W. Ekere, J. Olupot). At the suggestion of biological scientists, the economic analysis of the impact of IPM CRSP activities on groundnut production will continue for one more year (J. Bonabana, E. Adipala, S. Kyamanywa, G. Luther, H. Warren)

f. **Justification:** IPM CRSP interventions must be evaluated from both a biological science and an economic perspective. It is possible that interventions viewed favorably from a biological perspective, will not be economically viable. Conversely, it may the case that interventions that do not appear to be superior from a biological perspective, are profitable from an economic perspective if they sufficiently reduce production costs and/or the risks of production (as was demonstrated in our post-harvest storage work). Socio-economic research is essential to assess profitability of technologies and impacts on food security, poverty reduction and sustainable resources use. The basic economic analyses are crucial components in the assessment of the economy wide impacts of IPM CRSP activities as well as their potential spillover effects. Given the complexity of factors influencing agricultural production and marketing, substantial empirical research is still needed to investigate the feasibility and social acceptance of IPM CRSP technologies in Uganda.

g. **Relationship To Other IPM CRSP Activities:** As indicated in the discussion of new and continuing activities above, interaction will take place with many of the biological scientists involved in some aspect of IPM CRSP research. While resource limitations preclude an economic assessment of every aspect of the project, the majority of the project's activities will undergo some form of economic evaluation.

[8] M. Amujal's M.S. thesis.

**h.** **Progress to Date:** Data collection has been partially completed for the economic assessment of sorghum trials. Jackline Bonabana, Basil Mugonola, and Magdalena Amujal have developed their M.S. thesis proposals, and have begun their research. A preliminary cost-benefit analysis of the impact of predatory ants on termite damage to maize fields was conducted. Field data collection forms are being finalized. Field level economic impacts of IPM CRSP technology on cowpeas have been assessed, and the analysis will now be expanded to post harvest impacts. The economic assessment of tomato production has been completed. Papers are being prepared for publication on the farm level impacts of IPM CRSP technologies on groundnuts and cowpeas, potato, and tomato. A paper entitled "The Economic Importance of Farm Level Bruchid Control in Stored Dry Beans and Cowpeas in Uganda" has been published in *MURIK Bulletin*, V2. Another paper "Farm Level Evaluation of Monocropping and Intercropping Impacts on the Returns to Maize yields in Iganga," has been published in *East African Journal of Rural Development*, V17.

**i.** **Projected Outputs:** (1) Journal articles are being submitted on the economics of IPM CRSP interventions on groundnut, tomato, potato, and cowpea production. (2) Three Ugandans will receive M.S. degrees - one from Virginia Tech, and two from Makerere University, completing studies on IPM technology adoption, impact of farmer field schools, and the economics of Maize production. (3) Papers will be presented at professional meetings and submitted for publication as the opportunities arise.

**j.** **Projected Impacts:** The impact assessment work will provide a framework for further impact assessment of technologies developed by the IPM CRSP in Uganda. Multi-disciplinary collaboration between social scientists and biological scientists will be enhanced. The analyses will provide information on socially acceptable and economically viable technologies.

**k.** **Projected Start:** September 29, 2002

**l.** **Projected Completion:** Continuing activity: December 31, 2002; New activity: September 28, 2003

**m.** **Projected Person-Months of Scientists time per Year:** 24

**n.** Budget: Makerere – $15,765; VT – $21,133; OSU – $5,820

### IV.2. IPM Information Development and Transfer: Assessment of Extension Staff Knowledge of IPM

**a.** **Scientist(s) Names and Institutional Affiliations**: Paul Kibwika - Dept. of Ag. Extension Educ., Makerere University; Mark Erbaugh - The OSU; Edison Mwanje - Extension Agent, Iganga District; Valdo Odeke - Extension Coordinator, Kumi District.

**b.** **Status**: Continuing Activity

**c.** **Overall Objective**(s): (1) Develop a survey and instrument and sampling frame; and (2) Conduct a survey in 10 districts of extension agent awareness and knowledge of IPM.

**d.** **Hypotheses**: The hypothesis that will guide this study is that extension agents are not knowledgeable of IPM and related knowledge. A sub-hypothesis is that extension agent background characteristics (age, education level, experience, gender, occupational status (rank), contact with NGO are positively associated with knowledge of IPM.

**e.** **Description of Research Activity**: A survey of 200 extension agents in 10 districts of Uganda will be conducted late 2002 or early 2003. The survey instrument will draw from questions used to assess extension agent knowledge of IPM in Iganga. The sampling frame will be randomly selected from lists of extension agents available at the district level. All questionnaires will be completed individually by extension agents at group meetings in each district.

**f.** **Justification:** "Failure of most IPM programs is a deficiency in extension particularly education and awareness of IPM technology" (Morse and Buhler, 1997). The current level of IPM knowledge among extension agents in Uganda is not known. A pilot assessment of extension agent knowledge and awareness of IPM was conducted with 8 extension agents in Iganga/Mayuge, in March 2001. This study indicated that extension agents had a limited awareness of IPM and a moderate level of IPM knowledge. This level of knowledge is considered inadequate if IPM is going to be institutionalized and disseminated to a larger audience in Uganda. Thus, this survey seeks to provide a more comprehensive assessment of extension agent knowledge and knowledge gaps of IPM. Information derived from the survey will help plan and target future IPM training for extension agents.

**g.** **Relationship to other CRSP activities at the site**: This work relates directly to Uganda Site efforts to disseminate IPM and IPM CRSP technologies to a broader audience.

**h.** **Progress to date**: A pilot assessment of extension agent knowledge and awareness of IPM was conducted with 8 extension agents in Iganga/Mayuge, in March 2001. This study indicated that extension agents had a limited awareness of IPM and a moderate level of IPM knowledge.

**i.** **Projected Output(s):** (1) A journal article for either African Crop Science Journal or East African Journal of Rural Development; (2) PhD dissertation at Penn State University.

**j.** **Projected Impacts**: Information derived from the survey will help develop training plans that for future IPM training programs for extension agents.

**k.** **Projected Start**: October 1, 2002

l. **Projected Completion**: September 1, 2003

m. **Projected Person-Months of Scientists Time per Year**: 3-4

n. **Budget**: Uganda – $5,665; OSU – $3,000

## IV.3 Support for International Conference on IPM in Sub-Saharan Africa

a. **Scientists:** Site Chair, Coordinator and Symposium Coordinator

b. **Status:** continuing

c. **Objective:** Post conference support to edit and publish proceedings and promote regionalization.

d. **Hypothesis:** N/A

e. **Description of Activity:** A special edition of the African Crop Science Journal will be produced following the symposium

e. **Justification:** An IPM symposium in Uganda is considered important at this junction in order to facilitate scientific synergism and promote regional collaboration**.**

f. **Relationship to other CRSP activities:** Will provide a platform for discussing IPM in sub-Saharan Africa.

g. **Progress to date:** The symposium dates are set for September 8-12, 2002

h. **Expected outputs:** The proceedings will represent the symposium output, will spread the results of the symposium, and further regionalization of the IPM CRSP.

i. **Expected impacts:** Enhanced regional attention and awareness of IPM

j. **Projected Start:** October 2002

k. **Projected Completion:** May 2003

l. **Person months:** N/A

m. **Budget: $6,600**

## IV.4 Geographic Information Systems To Enhance IPM Collaborative Research in Uganda: Follow-up to Solidify GIS Knowledge and Skills

**a.** **Scientist(s) Names and Institutional Affiliations**: E.A. Roberts (Virginia Tech); L.S. Grossman (Virginia Tech); S. Kyamanywa (Makerere University); National Agricultural Research Organization.

**b.** **Status: New or Continuing Activity:** Continuing

**c.** **Overall Objective(s):** The purpose of this project is to provide continuing Geographic Information Systems (GIS) support to collaborating agricultural scientists in Uganda. This will be done by building on the foundation for implementing GIS as a functional component of pest management research in Uganda which was laid by the authors in a three-day workshop conducted in Kampala in February of 2002. In follow up visits, an experienced GIS professional will work closely with a small number (5 or 6) of researchers to address the use of GIS in their individual projects. Training options include small informal group sessions, informal consulting with individuals, and field visits with researchers to assist with the collection of spatial data and to consult on possible GIS applications in individual projects. The Ugandan researchers who would be chosen for this continued training should be selected from those who participated in the original workshop and are using GIS or show promise for GIS in their programs.

**d.** **Hypotheses:** (1) skills learned in a workshop setting need to be cultivated in a more intense learning environment that focuses on individual projects. (2) continued interaction with those initial workshop participants who are actually using GIS will cement their use into the researchers' repertoire of analytic tools.

**e.** **Description of Research Activity:** No research. Informal student tutorial sessions in a one-on-one or small group format.

**f.** **Justification (relation to IPM-CRSP objectives and priorities):** While short intense workshops of the kind presented in 2002 are a good forum to expose researchers to GIS tools and concepts, experience has shown that users often become overwhelmed, frustrated, and confused when applying these tools to actual field problems, resulting in high rates of attrition. Previous experience with GIS implementation funded by the IPM CRSP in Jamaica demonstrates the benefit from having post-training visits to individuals learning these tools. In addition, experience has shown that only a fraction (15 to 25%) of original participants continue using the tools. It is these few who deserve continued support. Follow-up visits to training sites also helps local users to broaden their grasps of associated tools and concepts such as data management as well as the procurement of data.

**g.** **Relationship to other CRSP activities at the site:** Use of GIS will complement and enhance the work of those currently focusing on the introduction of resistant varieties, the factors affecting pest outbreaks (such as the groundnut leaf miner), the socio-economic influences on IPM adoption, and pest problems associated with crop storage, as well as other research issues related to IPM.

**h.** **Progress to date:** In February of 2002, Lawrence Grossman and Andy Roberts of

Virginia Tech presented an intense 4-day GIS workshop with 16 participants from Uganda and one from Democratic Republic of Congo. The groundwork for this workshop had been laid in March 2001 when Grossman visited Uganda to discuss plans, meet cooperators, and collect data.

**i.** **Projected Outputs:** Enhancement of both knowledge base and skill sets in GIS along with experience in using these tools for

**j.** **Projected Impacts:** Continued training in the techniques of GIS and GPS will address the following needs: (1) provide a database system for managing and storing IPM data; (2) enhance analysis of data to reveal relationships among variables; (3) encourage scientists to think and interpret their data from a spatial perspective; (4) stimulate hypothesis formation to facilitate additional research; (5) increase the ability to visualize relationships among variables; (6) combine environmental, agricultural, and socio-cultural data in analyses; and (7) improve the ability of scientists to communicate and share the results of their research.

**k.** **Projected Start:** October 1, 2002

**l.** **Projected Completion:** September 30, 2003

**m.** **Projected Person-Months of Scientists Time per Year:** 1 month

**n.** **Budget:** $4,000 – Virginia Tech

## V. IPM CRSP Uganda Site Emergency Response Work Plan - Coffee Wilt

### Etiology, Epidemiology and Integrated Management of Coffee Wilt *(Fusarium xylarioides* (teleomorph = Gibberella xylarioides)

Dr. Sally Miller, Plant Pathologist, The Ohio State University
Ms. Melanie Ivey, Plant Pathologist, The Ohio State University
Dr. J. Mark Erbaugh, IPM CRSP Uganda Site Chair, The Ohio State University
Dr. Herman Warren, Plant Pathologist, Virginia Tech

**Introduction:** Coffee is the dominant commodity in Uganda's economy. The crop provides employment and income to 2.5 million Ugandans and continues to be the major foreign currency earner, accounting for 51% of total export in 1997. Coffee wilt caused by *Fusarium xylarioides* came into Uganda in 1993. It has spread at an alarming rate and is now known to be present in 25 districts. In some districts, 40-50% of the robusta coffee trees have been affected, and some fields have been completely destroyed and abandoned. The most promising approach to control this disease is development of resistant cultivars, and fortunately, it appears that sources of resistance are available. The information generated by activities contained in this work plan will be of great utility to breeders and others attempting to develop alternative control practices.

USAID/Kampala and the Ugandan National Agricultural Research Organization (NARO) requested emergency assistance from the IPM CRSP to help find solutions to the new and devastating disease of robusta coffee: Coffee Wilt (*Fusarium xylarioides*). From October 9 –21, 2000, a three person team fielded by the IPM CRSP, worked closely with NARO scientists at the Coffee Research Institute (CORI), to develop specific research plans and budgets that would address gaps in knowledge of the Etiology, Epidemiology and Integrated Management of Coffee Wilt (*Fusarium xylarioides*). The draft work plan and budget presented below is the product of this combined effort by the IPM CRSP and CORI team. These ideas were fully vetted in subsequent meetings with the NARO Director General, USAID/Kampala, and the Uganda Coffee Development Authority.

**Acknowledgements**: The IPM CRSP team would like to express its appreciation to USAID/Kampala and the IPM CRSP Management Entity for providing funding support and to NARO for providing complete and comprehensive facilitation and cooperation. In particular, we would like to acknowledge the efforts and contributions by Mr. Pascal Musoli, Coffee Breeder, and Dr. Georgina Hakiza, Interim Director, and Plant Pathologist, both of the Coffee Research Institute (CORI).

**Etiology, Epidemiology and Integrated Management of Coffee Wilt**

**1.1 Etiology of Coffee Wilt**

**a. Scientists:**

| | |
|---|---|
| Dr.G.J. Hakiza | Pathologist (lead scientist) |
| Dr. A. Kangire | Pathologist |
| Dr. S. Miller | Ohio State University |
| M. Ivey | Technician OSU |
| P.C. Musoli | Breeder |
| Dr. D. Kyetere | Breeder |
| P. Aluka | Breeder |
| S. Olal | Technician |
| C. Kabole | Technician |

**b. Objectives:** Coffee wilt is caused by Fusarium xylarioides (teleomorph = Gibberella xylarioides). DNA typing done by the International Mycological Institute indicates that the strain, which attacks arabica coffee in Ethiopia, is different from the strain, which attacks robusta coffee in Uganda. This research will provide information on the differences in *F. xylarioides* strains found in Uganda.

**c. Hypothesis:** In different districts in Uganda, there are different strains of *Fusarium xylarioides* that vary in their aggressiveness to different robusta genotypes.

**d. Description of Research Activity:** Specimens showing coffee wilt symptoms will be obtained from ten districts, selected west to east, across Uganda, and *F. xylarioides* will be isolated from samples. Cultures of the fungus from each district will be used to inoculate cuttings from five robusta cultivars that differ in susceptibility to coffee wilt based on previous tests and one arabica cultivar. A Ugandan scientist will take strains of the fungus showing differences in aggressiveness to robusta coffee to a laboratory in the U.S.A for DNA typing and learning the techniques used in this process. These strains will be compared with strains found in other countries.

**e.** **Justification:** Relatively little is known of different strains of *Fusarium xylarioides* that cause coffee wilt. Coffee breeders need information on differences in aggressiveness of strains of this fungus to robusta coffee. It is possible that resistance in lines developed during breeding could be overcome by changes in the genotype of the fungus. Coffee breeders need the ability to distinguish strains of *Fusarium xylarioides* by DNA typing to more readily detect genetic changes in the fungus.

**f**. **Project output:** Information will be obtained on *Fusarium xylarioides* strains currently in Uganda.

**g**. **Project impact:** Information on different strains of the coffee wilt fungus is needed by coffee breeders to develop resistant cultivars.

**1.2 Epidemiology of Coffee Wilt**

**a.** **Scientists**:

| | |
|---|---|
| Dr.G.J. Hakiza | Pathologist (team leader) |
| Dr. A. Kangire | Pathologist |
| P.C. Musoli | Breeder |
| Dr. D. Kyetere | Breeder |
| M.P.E Wetala | Agronomist |
| Dr. Herman Warren | Virginia Tech |
| Dr. Ira Deep | The Ohio State University |
| S. Olal | Technician |
| C. Kabole | Technician |

**b.** **Objectives**: Investigations on inoculum source and spread of coffee wilt disease will determine whether the pathogen is (1) soil borne (2) seed borne (3) produced on infected stems, leaves, husks (4) from alternative hosts such as banana and wild coffee, and /or transmitted by insects.

**c.** **Hypothesis:** The spread of coffee wilt disease to healthy coffee plants is the result of inoculum coming from one or more sources. Inoculum may be found in soil or infected seeds, produced on infected plant parts, may come from alternative hosts found near the healthy plants or may be carried to healthy plants by insect vectors.

**d.** **Description of research activity:**
***Study 1.2a***. Several techniques are available to determine whether soil is infested with the coffee wilt pathogen, *Fusarium xylarioides.* A biological assay will be conducted using coffee seedlings to trap the fungus. Five trees that have been killed by coffee wilt will be taken out, and soil samples will be collected from the root area within one week.

Coffee seedlings will be planted using controls and replication as needed. This process of sampling and assaying soil at these five tree sites will be repeated at one-month intervals until the fungus is no longer obtained.

***Study 1.2b.*** Coffee seeds collected from ten trees that have been killed by coffee wilt will be plated out on agar medium to determine the presence of *Fusarium xylarioides.* Two hundred seeds taken from each of the ten trees will be assayed.

***Study 1.2c***. Experiments will be setup to determine whether macroconidia of *Fusarium xylarioides* can be produced on stems, leaves or seed husks of coffee wilt infected trees and therefore serve as inoculum. Stems collected from ten coffee trees infected with wilt will be placed in a moisture chamber for 48 hours and examined for presence of macroconidia of *F. xylarioides.* Leaves from these ten trees will be treated in the same manner. Seed husks from coffee wilt infected trees will be surface sterilized and plated out on agar media to determine the presence of *F. xylarioides.* A Master's Degree Student in the Department of Crop Science, Makerere University will investigate the sources of *F. xylarioides* inoculum in infected coffee plantings: stems, leaves and seed husks.

***Study 1.2d.*** The coffee wilt fungus, *Fusarium xylario*ides, can attack all species of coffee and the fungus has been reported to attack bananas. Five coffee plantings will be located in which trees in the plantings are dying of coffee wilt and a forest is nearby. In each planting an area 100 meters into the forest will be surveyed for presence of wild coffee trees that are infected with coffee wilt. Samples from suspected trees will be collected, brought to the laboratory, and assayed for presence of *F. xylarioides*. Five coffee plantings will be located in which banana trees are interplanted with coffee and trees are dying from coffee wilt. Each planting will be surveyed for presence of banana plants that are infected with *F. xylarioides*. Suspected samples will be collected, brought to the laboratory, and assayed for presence of the fungus.

***Study 1.2e.*** To determine whether insects may transmit the pathogen, insects will be collected from coffee plantings where coffee is infected, plated out on differential agar media that favor *Fusarium* species and cultures identified.

***Study 1.2f.*** In naturally infected coffee fields on-farm and on-station at CORI, 128 (8x16) coffee trees will be marked for observation and recording at 4 weekly intervals. Initially, the health status of all 128 trees marked will be recorded. The pattern of wilt spread from tree-to-tree will be indicated at each recording. Presence of the pathogen with increasing distance from infected trees and with depth in soil will be established. Spores will be trapped using greased glass slides placed at variable heights in coffee fields at Kituza to assess spore dispersal. Other information to be collected will include geographical location, altitude, management practices, slope of land, and soil type.

**e.** **Justification:** This research will attempt to determine the sources of inoculum that initiate the disease in a planting, and that provide for subsequent spread of disease throughout the planting. Establishment of the disease in a planting commonly leads to death of all the trees. Knowledge of source of inoculum will lead to better disease management through changes in cultural practices.

**f.** **Project output:** Increased knowledge of the Epidemiology of this disease will be obtained.

**g.** **Project impacts:** Knowledge of sources of inoculum for both primary and secondary infection will be helpful to breeders and may help in cultural control of the disease.

## 1.3 Host-parasite relationship

**a.** **Scientists**:

| | |
|---|---|
| Dr.G.J. Hakiza | Pathologist (Lead scientist) |
| Dr. A. Kangire | Pathologist |
| P.C. Musoli | Breeder |
| Dr. D. Kyetere | Breeder |
| P. Aluka | Breeder |
| Dr. Herman Warren | Virginia Tech |
| Dr. Ira Deep | Ohio State University |
| S. Olal | Technician |
| C.Kabole | Technician |

**b.** **Objectives:** To determine the methods of penetration, infection and invasion of coffee plants by *Fusarium xylarioides* by examining: (1) the point of infection; (2) invasion of host tissue following penetration; and (3) the relationship of age of tissue to infection.

**c.** **Hypothesis:** During development of coffee wilt disease, (1) points of infection include roots, stems and/or leaves; (2) the fungus moves into different tissues in the plant; (3) rapidity of invasion of host tissue by the fungus is related to age of coffee trees.

**d.** **Description of research activities:**

***Study 1.3a.*** Genotypes with varying degrees of susceptibility will be inoculated with a spore suspension ($1.3 \times 10^6$) of *Fusarium xylarioides*. Five cuttings of each genotype will be sprayed with inoculum and placed in a moisture chamber for 36 hours in the screen house. Treatments will consist of wounded and unwounded stems, leaves, and roots. Ten samples from each treatment will be examined with the microscope to determine visually if penetration and growth of the fungus occurs. Two weeks after removing plants from the moisture chamber 20 sections of stems, leaves and roots will be plated on agar medium and observed for *F. xylarioides*.

***Study 1.3b.*** Tissue from plants that have been infected by the fungus will be examined microscopically for growth and development of the fungus in the tissue. Diseased host tissue will be sectioned, stained and examined for fungal mycelium and propagules in the xylem, phloem, cambium and cortex to determine what host tissues are invaded. A Master's Degree student in the Department of Crop Science, Makerere University will determine which coffee tissues are invaded by F. xylarioides: roots, stems, leaves –

xylem, phloem, cambium, cortex.

***Study 1.3c.*** Ten plants from three genotypes with varying degrees of susceptibility will be studied from flowering period to harvest. Tissues will be examined at the onset of flower budding, mid maturity, prior to harvest and two months after harvest. A monitoring system that consists of fields with different ages of plants will be observed for symptom development. One hundred trees will be tagged and plants in each age group observed for disease development. The incidence of diseased plants will be recorded.

***Study 1.3d***. A study conducted in an established coffee planting will demonstrate whether penetration may occur through wounds created during weeding and pruning. Treatments will include creating wounds by mechanically chopping out weeds thus creating wounds in roots near the soil surface versus weeding by use of herbicides or mechanical action that does not wound the roots. Treated root surface areas will either be inoculated with *F.xylariodes* macroconidia or left uninoculated. It is common to prune out new stems coming from adventitious buds at the base of the tree. The wounded areas of the tree will be tagged and examined later for presence *of F. xylarioides* by culturing the fungus.

***Study 1.3e***. Studies will be carried out to determine whether factors such as temperature, light, surface wetness, pH, affect spore germination, germ tube growth and penetration of host tissues. Stem sections of 3-6 months old coffee seedlings inoculated with *F. xylarioides* will be stained and examined for post penetration events such as formation of barriers, toxins, etc., within the host tissues. The specimens will be sectioned after 2 hours, 2 weeks, 4 weeks, at symptom appearance and at an advanced stage of disease development.

**e.** **Justification:** There is little information on host-parasite interactions. This research will determine how the fungus penetrates and invades the host tissue. The information will aid pathologists and breeders in development of control strategies.

**f.** **Project output:** Points of infection and invasion will be determined; this knowledge will contribute to development of rapid methods for evaluation of germplasm and development of an overall management scheme to control coffee wilt.

**g.** **Project impact**: Development of management practices to control coffee wilt will result in higher income and security for small-scale farmers.

## INTEGRATED PEST MANAGEMENT – COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), AFRICA SITE IN UGANDA

(October 1, 2002 – September 30, 2003)

| ACTIVITY | | SCIENTISTS | BUDGET ($) |
|---|---|---|---|
| **HIGH COMMERCIAL VALUE LEGUME CROPS ASSOCIATED WITH HIGH PESTICIDE USE** | | | |
| I.1.1 | Integrated Management of Cowpea Insect Pests and Diseases | E. Adipala, S. Kyamanywa – Makerere; G. Luther, – VA Tech.; J. Mbata – FVSU; R.B Hammond, M. Erbaugh – OSU. | Makerere $ 14,060<br>OSU $ 3,780<br>VA Tech $ 2,937<br>FVSU $ 8,450 |
| I.1.2 | Integrated Management of Groundnut Insect Pests and Diseases | E. Adipala, S. Kyamanywa – Makerere; G. Luther – VA Tech; A. Agona –NARO/KARI; C. Busolo-Bulafu, Kumi; R.B. Hammond, M. Erbaugh – OSU. | Makerere $ 22,530<br>OSU $ 3,906<br>VA Tech $ 2,809 |
| **IMPORTANT CEREAL CROPS ASSOCIATED WITH FARMING SYSTEMS IN EASTERN UGANDA** | | | |
| I.2.1 | Integrated Pest and Disease Management Strategies for Maize In Uganda | G. Bigirwa, Kalue, Sekamati – NARO/NAARI; R.C. Pratt, R. Hammond – OARDC, OSU; E. Adipala – Makerere. | Makerere $ 13,805<br>OSU $ 21,672 |
| I.2.4 | Development of novel options for *Striga* management for small holder sorghum farmers | J.R. Olupot – SAARI/NARO; H. Warren – VA Tech. | Makerere $ 5,458<br>OSU $ 6,002 |
| **DEVELOPMENT OF IPM STRATEGIES FOR HIGH VALUE HORTICULTURAL CROPS** | | | |
| II.1.1 | Development of IPM Technologies for Tomato Production in Central Uganda | M.C. Akemo, S. Kyamanywa – Makerere; R. Hammond, Grewal – OSU; V. Kasenge – Makerere; M. Olanya – CIP. | Makerere $ 15,147<br>OSU $ 7,560 |
| **POST-HARVEST MANAGEMENT OF MOULDS AND MYCOTOXINS IN MAIZE AND GROUNDNUTS** | | | |
| III.1.1 | Moulds and Mycotoxins in Maize and Groundnuts in Uganda | A.N. Kaaya, E. Adipala, S. Kyamanywa – Makerere; H. Warren – VA Tech; A. Agona – KARI; G. Bigirwa – NAARI. | Makerere $ 8,806<br>VA Tech $ 14,875 |
| III.2.1 | Splitting Cowpea effect on biology of C. maculates, quality attributes and marketability of cowpea seeds. | A. Agona, S. Kyamanywa, A.Kaaya, H. Warren, J. Bonabana, V.Kasenge, W.Ekere, M. Erbaugh & D. Taylor | Makerere $ 3,850<br>VT & OSU (see socio-econ. Below). |

| SOCIO-ECONOMIC ASSESSMENT, INFORMATION DISSEMINATION AND REGIONALIZATION | | | | |
|---|---|---|---|---|
| IV.1 | Socioeconomic Assessment of IPM CRSP Technology Development Activities in Uganda | V. Kasenge, W. Ekere, J. Bonabana, B. Mugonla, Ogwang – Makerere; V. Odeke – Extension Crop Protection Specialist; D.B. Taylor – VA Tech; J.M. Erbaugh – OSU; | Makerere<br>VA Tech<br>OSU | $ 15,765<br>$ 21,133<br>$ 5,820 |
| IV.2 | IPM Information Development and Technology Transfer | P. Kibwika – Makerere; M. Erbaugh – OSU; Dan Taylor – VA Tech; S. Kyamanywa – Makerere; G. Luther – VA Tech. | Makerere<br>OSU | $ 5,665<br>$ 3,000 |
| IV.3 | Regional IPM CRSP Symposium | E. Sabiiti, S. Kyamanywa – Makerere; G. Bigirwa, – NARO; C. Omwega – ICIPE; A. Ekwamu – Rockefeller Forum. | Makerere | $ 8,800 |
| IV.4 | Geographic Information Systems To Enhance IPM Collaborative Research in Uganda | E.A. Roberts, – VA Tech; S. Kyamanywa – Makerere; NARO | Makerere<br>VA Tech | $ 1,375<br>$ 5,108 |
| **COFFEE WILT** | | | | |
| I.1 | Etiology of Coffee Wilt | G.J. Hakiza – CORI; S. Miller, M. Ivey – OSU. | CORI<br>OSU | $ 19,195<br>$ 27,849 |
| I.2 | Epidemiology of Coffee Wilt | G.J. Hakiza, D. Kyetere – CORI; H. Warren – VA Tech. | CORI<br>VA Tech | $ 35,541<br>$ 8,979 |
| I.3 | Host-Parasite Relationship | G.J. Hakiza, D. Kyetere – CORI; H. Warren – VA Tech. | CORI<br>VA Tech | $ 28,133<br>$ 15,304 |

# Year 10 Workplan for the Central American Sites in Guatemala and Honduras

Tenth year IPM CRSP program activities in the Guatemala/Honduras sites will include research, technical assistance, institutional strengthening, and program leadership in four major workplan areas: (1) socioeconomic, marketing, and policy analysis, (2) assessment of alternative cropping systems including biorational and organic approaches, (3) biological control techniques, and (4) strategically targeted disease and insect control.

## 1.1. Institutionalize performance standards for postharvest handling and regulatory compliance (including food safety) for achieving sustainable NTAE program development in Central America.

**a.** **Scientists:** G. Sullivan, J. Julian, S. Weller – PURDUE; G. Sánchez – ICADA

**b.** **Status:** Continuing activity

**c.** **Objective:** To quantify the impact of the US Food and Drug Administrations Import Alert mandating automatic detention for all snow pea shipments from none exempt exporters on the demand for Guatemalan snow peas in the US market.

**d.** **Hypothesis:** (1) Automatic detention of Guatemalan snow pea shipments at US ports of entry has resulted in US buyer uncertainty regarding Guatemalan snow pea quality (i.e. ability to meet market access requirements), and (2) The automatic detention of Guatemalan snow peas at US ports of entry has had a negative impact on the demand for Guatemalan snow peas in the US market.

**e.** **Description of research activities:** This research will assess US buyer attitudes toward Guatemalan snow peas and automatic detention, as well as, analysis international economic and trade data in order to determine if a correlation exists between the current downward trend in Guatemalan snow pea export quantities and prices and the import detentions that have been the result of automatic detention.

**f.** **Justification:** Guatemala was once the dominant supplier of US snow pea imports. The production and marketing activities associated with the snow pea export trade have benefited thousands of Guatemalans, particularly those in economically depressed rural regions. The decline in market share and the corresponding decline in export volume will likely have a negative impact on the rural population that began snow pea production as a means to improve their standard of living. Gaining an understanding of the causes of this decline is a crucial step toward reversing the current trend and improving the Guatemalan snow pea industry.

**g.** **Relationship to other CRSP research activities:** Provides addition support for the need to develop IPM production, post-harvest handling and pre-inspection programs to achieve regulatory compliance and economic sustainability in North American markets.

**h.** **Progress to date:** Completed assessment of the value and importance of quality assurance policies and procedures to the Guatemalan snow pea trade (Master's thesis and two journal publications). Developed research framework for the assessment of US snow pea buyers. Began initial data collection, collation, and assessment of international economic and trade data.

**i.** **Projected outputs**: (1) Market assessment that quantifies the need for IPM CRSP performance protocols and the implementation of Good Agricultural Practice (GAP), as well as, post-harvest handling protocols (pre-inspection) to achieve regulatory compliance and long-term sustainability of NTAE programs, (2) increased standard of living and income stability for NTAE producer households, (3) Ph.D. thesis and two journal publications.

**j.** **Projected impacts**: Increased food safety compliance requirements jeopardize future access to US markets for Central American NTAE producers and exporters. The automatic detention of Guatemalan snow pea shipments has been an impediment to competitiveness in this market, as well as, impacting the export trade of other NTAE crops. Addressing the issue of automatic detention, and GAP protocols for sanitary and phytosanitary compliance, is essential for long-term sustainability of Guatemalan NTAE export programs at the small producer and community levels in Central America.

**k.** **Projected start**: September 29, 2002

**l.** **Projected completion**: December, 2003

**m.** **Projected person-months of scientist time per year**: 3 person-months

**n.** **Budget**: PURDUE - $42,831 (IPM CRSP)

## 1.2 Assessment of the impact on rural health of IPM CRSP technology adoption in the NTAE snow pea production system

**a.** **Scientists:** G. Sánchez – ICADA; L. Asturias ESTUDIO 1360; S. Hamilton – VIRGINIA TECH

**b.** **Status:** Continued activity

**c.** **Objectives:** *Overall:* Establish through survey data and health related bioassays a baseline for rural health within and outside the IPM CRSP NTAE fully integrated, grower-operated snow pea production area and if positive results are obtained, develop protocols for using information gained in the assessment to demonstrate how rural health can be impacted in a positive manner wherever NTAE crops are grown in Central America using the IPM CRSP model. *Year 10:* (1)

finish analyzing data gathered in April 2002 through survey of IPM CRSP and non-IPM CRSP NTAE snow pea producers, their families, and field workers on health related issues and through bioassays, (2) develop a model for recommendations and interventions to improve rural health based on the findings of the surveys and bioassays, (3) publish results.

d. **Hypothesis:** Rural health is being positively impacted through the transfer of IPM CRSP-developed NTAE snow pea production systems in Guatemala.

e. **Description of research activity:** A survey/analysis/assessment of the impact of the NTAE snow pea system on rural health was carried out in Year 9. The survey focused on IPM CRSP NTAE snow pea producers, their families, and field workers and a similar set of non-IPM CRSP NTAE snow pea producers, their families, and field workers. Both assessments related to the status of test subject health and environmental impact of IPM CRSP protocols on TTO in sample-population and water supplies were addressed in research methodology.

f. **Justification:** It is believed, although not proven at this point, that the adoption of the IPM CRSP-based NTAE production systems is positively impacting the rural health of test populations. It is also possible that through the adoption of research-based pest management systems for NTAE crops that the IPM CRSP is impacting how non-NTAE domestic crops are grown on the CRSP farms, and thus the overall enhancement of rural health. For example, by raising water quality standards for the production of NTAE crops, locals will likely raise the quality standards of the water that is used in the production of domestic foods, as well as that used for drinking and cooking. This has a positive impact on rural health. Additionally, by addressing issues related to harmful microorganisms such as cyclospora, and eliminating their presence on or in NTAE crops through the adoption of sanitary and phytosanitary standards, demand for safe food and water should increase.

Through the utilization the of biorational pest management practices developed through the IPM CRSP, farmers use less pesticides and this should improve rural health. There is less contact with TTO resulting in decreased health risks and improved rural health. It has been shown in the IPM CRSP, for example, that producers of the NTAE crop snow peas reduce pesticide applications from approximately 25 to about 4. This reduces producer costs and provides environmental and human health savings. Pesticides are known to manifest in the food chain as well exhibit a direct toxicity to human neurotissue. This project proposes to gauge the impact of these IPM CRSP related NTAE sanitary and phytosanitary changes, as well as the implementation of biorationally-based pest management production systems, on rural health and to provide the vehicle for this to play a role in the adoption of IPM CRSP-based pest management and production technology.

g. **Relationship to other CRSP activities:** The IPM CRSP has developed a biorationally-based pest management system through a series of research projects for the production of snow peas in Guatemala. This system has proven that snow peas can be produced with significant reductions in chemical inputs with the output of high quality, safe commodity as the end product. This has resulted in a significant reduction in detentions of snow peas at U.S. ports of entry. Up to this point, there have been no studies on the relationship of IPM CRSP projects in Guatemala to health outcomes.

**h.** **Progress to date:** The survey instrument was developed by IPM CRSP project personnel and the final draft was then evaluated by the Institute for Nutrition for Central America and Panama (INCAP) and approved for use in the target area of Chimaltenango. INCAP personnel, along with Edwards and Reavis, took the necessary data in the targeted village in April 2002.

A proposal has been submitted to United Nations Food and Agriculture Organization (UN FAO) Guatemala and Government of Guatemala officials for funding of a UN FAO Technical Cooperative Program (TCP) on the impact of the IPM CRSP on rural health and the CRSP is waiting word on its status. The proposal submitted to USEPA, Government and International Services Branch, Office of Pesticide Programs, was not funded at this time, but EPA indicated interest in this project and said they would consider it for future funding. Agencies and organizations in Guatemala that were asked to participate in both of these projects are UN FAO, INCAP, USAID-Guatemala, Ministry of Agriculture, Livestock, and Food (MAGA), Ministry of Public Health and Social Assistance (MINSA), and Center for Disease Control (CDC) Guatemala.

**i.** **Projected outputs:** (1) Quantification that the IPM CRSP NTAE project related to snow peas has resulted in a reduction of negative human health impacts and thus has improved rural health, (2) quantification that non-NTAE grown products in the NTAE snow pea area are benefiting from IPM CRSP technology transfer and that rural health is being enhanced by technology adoption, and (3) interventions based on research findings about TTO and bioassays will improve rural health in test populations.

**j.** **Projected impacts:** (1) Increased adoption of IPM CRSP technologies for NTAE and non-NTAE (domestic) crops, (2) improved rural health of test populations, and (3) transfer of outcomes to other populations in NTAE areas.

**k.** **Project start:** September, 2000

**l.** **Projected completion:** September, 2003

**m.** **Projected person-months of scientist time per year:** 6 person-months.

**n.** **Budget:** PURDUE - ICADA/Hamilton -$11,359 (FAS/GOG)

### I.3. Economic and socioeconomic impact assessment of IPM and nontraditional crop production strategies on small farm households in Guatemala.

**a.** **Scientists:** S. Hamilton – VIRGINIA TECH; G. Sánchez – ICADA; G. Sullivan - PURDUE; L. Asturias de Barrios - ESTUDIO 1360

**b.** **Status:** Continuing activity

**c.** **Objectives:** *Overall:* (1) To increase economic and social benefits of IPM; (2) To measure the economic and social impacts of IPM adoption; and (3) To measure economic and social constraints of IPM adoption. *Year 10:* (1) To continue assessment of financial constraints to adoption and sustainable growth in production of targeted crops. (2) To continue assessment of marketing constraints to adoption and sustainable growth in production of targeted crops. (3) To assess the role of producer organizations in adoption and practice of IPM and in sustainable production of targeted crops. (4) To assess the role of social capital in producer organizations.

**d.** **Hypotheses:** (1) Access to credit increases likelihood of adoption and continued production of targeted crops. (2) Membership in a producer organization increases likelihood of farmer's access to credit, marketing channels, and technical assistance in IPM. (3) Higher levels of social capital (trust, transparency, reciprocity norms, presence of accepted rules and roles for leaders and members) in production-related organizations increase likelihood of sustainable financial, marketing, and pest management processes.

**e.** **Description of research activity:** Research will involve information collection, description, and analysis of (1) production-related organizations available to small-scale producers of nontraditional export crops in Chimaltenango and (2) effects of these organizations on the production and marketing of NTAEs, economic and social benefits for members, producer control of own labor and production and marketing processes, and adoption and practice of IPM. These organizations are expected to include community-based organizations, such as production, credit, resource-management, or other (often multi-purpose) cooperatives; second-level, regional cooperatives; and membership-based group production contracting organizations. The organizations will be analyzed in terms of membership basis, political structure, history, commodity-chain positioning and functions, vertical and horizontal ties with other organizations (including export companies), membership costs and benefits, and levels of social capital. Household/individual- level variables will include perceived costs and benefits of membership, production and marketing decisions impacted by membership, including those related to IPM, gender and intrahousehold resource allocation and decision effects of membership.

The research will involve (1) literature review concerning (a) meanings and utility of the concept *social capital* and (b) organizational structures, functions, and expected differential levels of social capital per type or geographical location of organization; (2) key informant interviews with organizations' leaders and members; (3) key informant interviews with community and household members; (4) community-based probabilistic-sample survey on (a) characteristics of members vs. nonmembers and (b) the social and economic impacts of the organizations. The amount of funding sought reflects the desire of the research team to include at least two communities, three types of organization, 20-30 key informant interviews, and a survey of 75 households.

**f.** **Justification:** This activity will identify organizational constraints to economically sustainable production of nontraditional export crops and to adoption of IPM. Past work on this project has demonstrated that most farmers are willing to adopt some, but not all, of the recommended IPM practices, and that the most difficult practices to transfer require sustained producer contact. Studies of producer organizations and social capital have shown that the most sustainable transfer of environmental protection practices tends to take place in organizations that are membership-based or community-based or meaningfully tied to membership and community groups. It has been hypothesized by some researchers (Katz, Fischer) that Maya farmers are possessed of traditions and social networks that can provide the social capital basis for organizational sustainability and for achieving desired economic and natural resource management results. Others (Carletto) contend that cooperative members have been self-selected among farmers who would have achieved better economic results with or without the cooperative. Most researchers posit that farmers and organizations achieve most sustainable results when farmers retain control of their own land and labor, rather than perceiving that they essentially work for the company or co-op.

Most IPM CRSP social research to date has been at the household level. This study will enable the CRSP to evaluate the role of a variety of organizations in helping farmers to achieve better economic and environmental results, and to evaluate the role of Kaqchikel Maya social formations in the process.

**g.** **Relationship to other CRSP activities at the site:** In household surveys during 1998-2001, farmers indicated (1) high level of self and family involvement in NTAE labor; (2) their continuing need for production credit, (3) high-level adoption of technology-based IPM but low-level adoption of scouting and other labor- and information-intensive practices; and (4) that they received better prices if they sold nontraditional export crops through production cooperatives and contracts with exporters than if they marketed independently. Access to membership in cooperatives and to contracts varied greatly among Kaqchikel communities in Chimaltenango and Sacatepéquez. Yet voiced need for credit and low adoption of information-intensive IPM were present in all communities. In 2002, a study of production and household finance was undertaken to help sort out the sources of informal and formal production credit available to farmers, associated risks, and farmer preferences among these sources. The research proposed for Year 10 will complement all of this work by effectively placing production-related organizations and their members vertically in commodity input and output chains and by analyzing in greater detail (1) how organizational structures and cultures impact members and vice versa and (2) the economic and social impacts of these organizations at the community and household levels.

**h.** **Progress to date:** Probabilistic household surveys were conducted in three Maya communities in 1998, 1999, 2000, and 2001. These dealt with social and economic effects of nontraditional export production in small farm households, adoption of IPM by these households, and perception of long-term economic and social impacts of NTAEs at the community level. Results of this research have been published in international journals (Goldin and Asturias de Barrios 2001; Hamilton, Asturias de Barrios, and

Tevalán 2001) and presented at international fora. Key informant data collection is being carried out in 2002 for the rural finance study. This work is multi-sited, as it involves formal and informal financial markets at the local, regional, national, and international levels. (Funding for the 2002 work was insufficient to cover a household survey, as proposed; key informant interviewing was substituted.)

i. **Projected outputs:** Minimum of one working paper and/or article presenting research results; presentation of policy recommendations for IPM information and technology transfer mechanisms to IPM CRSP site committee.

j. **Projected impacts:** Improved understanding of differential effects of production-related organizations on economic, social, and environmental impacts of nontraditional export production in the smallholder sector; improved understanding of IPM adoption processes among smallholders; ultimately, higher incomes, IPM adoption, and more sustainable production practices for small-scale producers of nontraditional export crops.

k. **Projected start:** October 2002

l. **Projected completion:** September 2003

m. **Projected person-months of scientist time per year:** 3

n. **Budget:** VPI/Hamilton $19,155 (IPM CRSP); ICADA/Hamilton $15,730 (FAS/GOG)

**II.1 Improved IPM production strategies for integration into prototype preinspection programs in NTAE crops.**

a. **Scientists:** S. Weller, G. Sullivan - PURDUE; G. Sánchez - UVG; C. Mayen (Guatemalan Graduate Student) – PURDUE.

b. **Status:** Continuing activity. Expanding and strengthening IPM research capabilities in NTAE vegetable and fruit crops in Guatemala through graduate student training. This research compliments and enhances work ongoing in our other projects, including production practices that impact implementation of IPM strategies and pesticide use in NTAE vegetables.

c. **Objectives:** *Overall:* To develop strong IPM research capabilities of Guatemalan cooperators in vegetable and fruit crop production; and to develop an IPM papaya production practices database to guide research programs in papaya pest management. Effective management of insects, diseases, and weeds to achieve improved growth, yield, and quality characteristics in all NTAE crops requires well trained personnel and well designed and executed research programs. *Year 10:* (1) Finish the database regarding pest and production problems facing Guatemalan papaya growers with emphasis on fruit flies (Med fly), (2) finish field plots for development of production practices that minimize pest problems in vegetable production systems.

**d. Hypothesis:** The use of improved pest management strategies in NTAE crop production systems will result in enhanced yields and reductions in pest levels and pesticide use.

**e. Description of research activity:** NTAE production practices using integrated approaches to manage pests will reduce pesticide and pest levels. The NTAE market is dependent upon consistent supply of high quality produce that is pest free, cosmetically acceptable, and free of pesticide residues. As with most crops grown commercially in Guatemala, production practices have relied on strategies imported from other countries. Our research will refine vegetable production practices to reduce reliance on external pesticide applications.

The work plan involves 3 main activities. First, the graduate student has been enrolled at Purdue University since August of 2000, and is taking classes to improve his scientific understanding of plant growth and pest management strategies, along with an emphasis on the genetics of crop improvement and molecular biological/biotechnology techniques. Purdue has an established international reputation in the area of plant biotechnology, genetics, and molecular biology. Secondly, research is developing an extensive data base of papaya pest management techniques with an emphasis on the scientific aspects of papaya cultivar responses to growing conditions and pest infestations. Our Guatemalan activities in association with this activity will emphasize work with APHIS on Med fly control and Med fly free zones. Third, research conducted at Purdue University is investigating the influence of cultural management techniques on pest control and population dynamics in fresh market tomato production systems. This research involves replicated field plots to test soil and cultural management technique effects on pest thresholds.

**f. Justification:** Improved scientific training is essential to better prepare students for the many challenges that need to be faced in improving Guatemalan agriculture. In order for performance proven IPM practices to be successful, we need to design not only improved production methods but also address varietal constraints and specific needs for new cultivar development. Research such as that described herein will allow development of programs that identify what plant characteristics contribute to productivity and response to pests. This research will identify characteristics that are essential to improved pest management practices in NTAE crops.

Purdue University is poised to integrate the information gained from this research into improved recommendations for vegetable and fruit production. In addition, these results will allow a determination of future pest management programs for papaya. The training obtained by the student will result in a production specialist with solid genetic and varietal improvement credentials. This professional will be able to utilize improved pest management practices and develop production systems that require reduced inputs of synthetic pesticides under Guatemalan conditions.

**g. Relationship to other CRSP research activities:** This activity emphasizes the strong collaborative objectives of IPM CRSP in the NTAE sector. Specific relationship with ongoing activities include: (1) documentation of traditional knowledge and practices (Purdue; VPISU, ICTA), (2) development of sustainable and expansionary NTAE strategies that incorporate performance proven IPM practices, reduce chemical use, and improve socioeconomic welfare (Purdue; UVG, APHIS; AGEXPRONT; ICTA), (3) strengthening the institutional research capacity and research collaborations in the host country (Purdue; UVG; ICTA; ARF/AGEXPRONT), (4) expedite the transfer of performance proven IPM research and technology to public and private sector institutions for implementation at the producer level (Purdue; APHIS), and (5) development of strategies that lead to expanded market opportunity through quality improvements in the NTAE sector at all levels (Purdue; ARF/AGEXPRONT).

**h. Progress to date:** The field aspects are beginning to consolidate our knowledge on how production practices can reduce pest infestation levels and lead to improved pest management. In a fresh market tomato experiment, three factors that could affect short and long term weed population densities are being tested: crop, soil management and threshold adoption. First year data demonstrated that crops with good canopy closure, like drilled soybeans, create an environment that allows less weed competition as the season progresses. On the other hand, an uncompetitive crop with wider rows, like fresh market tomatoes, allows weeds to germinate all season long. An alternative to conventional farming, winter rye cover crop suppressed broadleaf weeds for the first 4 weeks of the season. Weed control was not statistically different from the conventional approach, which relies on prophylactic herbicide applications and heavy tillage. And rye cover crop also reduced densities of morning-glory, a troublesome weed in tomato crops, until the end of the season. Even though the adoption of thresholds reduced the amount of inputs (herbicide and manual labor) for season weed control, certain weeds were present at the end of the season. Any weeds left until the end of the season, produced seed which enrich the soil seed bank. This year we will start to see the long term effects of crop, soil management and thresholds on the soil seed bank and weeds that consequently germinate during the season.

Literature pertinent to integrated pest management in papaya has been collected. Currently, the two most important phytosanitary problems for papaya growers are fruit flies and viruses. Thus we have focused on these two. A potential problem that is of major concern is mite and whitefly resistance to insecticides, as proven by a visit to the major papaya exporter in Guatemala, Frutas Maya. There are a few EPA approved insecticides for use in Papaya, thus alternative techniques need to be available to manage pest populations.
Both aspects of the research described here will compliment studies being undertaken by ICTA, UVG, and ARF/AGEXPRONT in tomatoes and papaya.

**i. Projected outputs:** The prime benefits of this project are twofold. First, the training of a skilled IPM researcher will benefit Guatemalan agriculture. Second, the research results will allow improved IPM in vegetables and in the development of papaya research programs focused on major problems facing growers. Both results will provide a basis for implementation of long-term IPM-based production practices for NTAE crops that reduce pesticide use and improve export market opportunities.

**j. Projected impacts:** The direct benefits will be to Guatemalan NTAE producers, processors, exporters, and U.S. consumers. Specifically this research will result in: (1)

improved production practices, (2) lower production costs and higher net returns for farmers, (3) reduced use of chemicals in production, (4) greater safety and lower human health risks, and (5) provide a basis for new research initiatives to improve papaya pest control.

**k.** **Projected start:** August, 2000

**l.** **Projected completion:** September 28, 2003

**m.** **Projected person-months of scientist time per year:** 12 person-months

**n.** **Budget:** PURDUE - $33,415 (IPM CRSP); ICADA/Weller - $13,424 ½ grad fee/assistantship (FAS/GOG)

**II.3 Assessment of insect pest and diseases, integrated pest management studies and development of PRSV-resistant plants in "solo-type" Hawaiian papayas.**

**a.** **Scientists:** G. Sánchez – ICADA; M. Palmieri – UVG; S. Weller, G. Sullivan – PURDUE; L. Calderon, D. Dardon – ICTA; W. Parrott, M. Deom - U. of GEORGIA

**b.** **Status:** Continuing activity

**c.** **Objectives:** *Overall:* (1) To determine the main pests (insects and diseases) affecting Hawaiian type papaya in Guatemala, including Papaya Ringspot Potyvirus (PRSV-potyvirus); (2) To study and generate integrated pest management programs for the control of the main pests affecting papayas; (3) To participate in the development of transgenic "solo–type" papaya, resistant to PRSV-potyvirus. *Year 10 objectives:* (1) To continue with the identification of insect pests and diseases, other than PRSV-potyvirus, affecting papaya orchards in Guatemala; (2) To test transgenic, putatively PRSV-resistant, papaya plants under greenhouse conditions and micropropagation of those plants retaining desirable agronomic traits; (3) To develop, following Pest Risk Assessment (PRA) guidelines, an ICM/systems approach for minimizing the risk of medfly/fruitfly infestations in export-quality papayas.

**d.** **Hypothesis:** (1) Satisfactory control of PRSV-potyvirus can be achieved by the generation, micropropagation and planting of transgenic papaya, resistant to PRSV-potivirus through coat protein resistance; (2) Satisfactory pest control (mainly *Ceratitis capitata* and *Anastrepha spp*) can be achieved by the implementation of tested and validated IPM programs, which minimize the risk of fruit fly infestation in export-quality papayas.

**e.** **Description of research activity:** This research will be an integration to previous efforts conducted by ARF-AGEXPRONT, the National Association of Papaya Producers (ANAPAPAYA) and PROFRUTA, the government's fruit research and promotion program. Universidad del Valle will become incorporated into this effort by conducting the genetic engineering studies in close collaboration with ICADA and ICTA. ICADA and ICTA will be in charge of conducting the field trials where integrated pest management programs will be designed for the main arthropod pests and diseases found in the field pest assessments. Therefore, the overall research will include: (1) Visits to the different papaya growing regions, check background information and assess the type and magnitude of damage caused by stem rotting, viral infections and any other diseases; (2) Identification and characterization of symptoms in the field, description, and establishment of photographic records; (3) Collection of diseased tissue and laboratory procedures for the identification of the causal agent; (4) Establishment of papaya orchards in two localities of Guatemala, one in Santa Rosa and one in Escuintla, to study and generate integrated pest management approaches for papaya; (5) Specific recommendations for diseases management and prevention, based on field observations, testing and laboratory analysis; (6) Through collaboration with The University of Georgia (Drs. Wayne Parrott (Soils and Crop Science Department; Dr. Michael Deom, Plant Pathology Department) plasmid vectors will be constructed, utilizing *Agrobacterium tumefasciens* as the vehicle for somatic embryogenesis transformations. The gene to be inserted will be a coat protein gene of PRSV strain indigenous to Guatemala. Somatic embryos of Sunrise papayas will be transformed, screened for successful transformation, regenerated and propagated in vitro; (7) Testing of in vitro regenerated transformants at the greenhouse and field levels will be pursued.

Items 1, 2, 3, 6 and 7 will be carried out by Universidad del Valle as the lead institution, while item 4 will be conducted by ICTA and ICADA. Item 5 will be generated through the collaboration of both institutions.

**f.** **Justification:** Exporting papayas to the USA represents a potentially very profitable investment for Guatemala, as previous IPM CRSP studies suggest an increasing demand for this product in the US for at least a decade in the future. However, serious limiting factors exist that prevent the establishment of this industry, such as the lack of up-to-date production practices, packing and export technology, several diseases (mainly PRSV) and pests (aphids, fruit flies and spider mites) and consumer preference studies in the USA. The IPM CRSP can play a crucial role in the development of a highly demanded, competitive and sustainable new export product in Guatemala, ensuring the implementation of adequate production and pest management programs that will ensure a high quality and safe product for final consumers. The development of PRSV-resistant papayas will avoid the usage of high quantities of pesticides to control the aphid vector resulting in added safety to the producers and consumers by reducing the pesticide chemical concentrations in the export product.

**g.** **Relationship to other IPM CRSP activities:** This study represents the interest of several Guatemalan collaborators in the search and expansion of the national non-traditional export crop sector. The private sector through AGEXPRONT, the Guatemalan government through PROFRUTA and the Unit of Norms and regulations, and the research institutions (UVG and ICTA), have all shown great interest in the establishment of a sustainable and competitive NTAE sector in Guatemala.

**h. Progress to date:** Transgenic papaya plants, both "solo" and local germplasm have been generated and successfully acclimated to greenhouse conditions. Presently we have only male plants, but pollen has been collected and manual polinization of female plants is under way to produce sexual seed containing the viral DNA. In vitro papaya transformants, obtained with the kanamycin vector have also been generated and are now in the process of differentiation into new plantlets. We expect to have between 50 and 100 transgenic papaya plants by the end of 2002, which will be used to conduct PRSV resistance assessments, as well as botanical and fruit characterizations.

**i. Projected outputs:** (1) Characterization and identification of the main plant pathogens and diseases infecting papayas in Guatemala; (2) Detailed description of symptoms and prevalence in the main growing regions; (3) Recommendations generated to apply integrated pest management strategies in the control of the identified diseases and their causal agents; (4) Production of effective coat-protein mediated PRSV resistant papayas.

**j. Projected impacts:** The main impact of this study will be the generation of adequate disease management recommendations, based on the identification of the causal agents involved. Through this effort, sound IPM programs can be implemented by growers and exporters to ensure the sustainability of this new industry by utilizing environmentally friendly and cost effective techniques. The future planting of PRSV-resistant Sunrise papayas will contribute to the reduction of pesticide usage as the main control tactic for PRSV insect vectors (aphids).

**k. Projected start:** October 1999

**l. Projected completion:** October 2003

**m. Projected person-months of scientist time per year:** 6 person-months

**n. Budget:** ICADA/Sanchez - $20,350 (IPM CRSP); ICADA/UVG - $13,750; (IPM CRSP); U. of GA - $3,250 (IPM CRSP)

## II.6 Identification, distribution, epidemiology and management of viral plant pathogens and insects that threaten solanaceous and cucurbit crop production in Honduras.

**a. Scientists:** D.T. Krigsvold, J.M. Rivera, J.C. Melgar, H.R. Espinoza – FHIA; A. Rueda, M. Mercedes Roca de Doyle, E. Aguilar – Zamorano; R. Martyn – PURDUE; G. Sullivan, G. Sánchez (CRSP Administration); J. Brown, Arizona (technical collaborator)

**b. Status:** Continuing activity

**c. Objectives:** *Overall:* The proposed activity was originally initiated as a three-year project in 2000/2001 (year 9). The first year's overall objective was the identification of the most economically important viral diseases of tomatoes, peppers and cucurbits, and though it is still valid, it has been expanded in this second year, primarily because the interaction among different plants and the pests affects the epidemiology of diseases necessitating the incorporation of a systems approach. As a result, this year's objectives are: (1) To continue identifying and determining the distribution of the most economically important viruses and their vectors in pepper, tomatoes and cucurbits in several economically important areas in Honduras**,** (2) The development and validation of an IPM program for Jalapeño and Tabasco pepper crops, including the evaluation of low environmental impact alternatives to chemical pesticides, and (3) Complete the initial stages towards the development of transgenic tomatoes and peppers resistant to the most common viruses. *Subsequent Years' Objectives:* (1) Identify and map the geographic distribution of the main plant viruses and their vectors present in the important cropping systems of Honduras. (2) Validation and technology transfer of IPM practices for insect pests of peppers. (3) Installation of the technology for virus identification and whitefly biotyping to FHIA and EAP. (4) Obtain infectious clones for the most important begomoviruses of tomato and pepper, which will be used in objective 5, below. (5) Make test constructs that will ultimately be employed in the development of transgenic Tabasco and/or Jalapeño peppers, and tomato (locally-adapted cultivars) with resistance to the most important pepper and tomato-infecting virus (es) in Honduras.

**d.** **Hypothesis:** (1) Aphid- and whitefly-transmitted plant viruses are important limiting factors in vegetable cropping systems in Honduras. Due to little information being available to farmers regarding specific plant viruses, disease control practices are often misguided, leading to application of chemicals that have no affect on virus pathogens. (2) Jalapeño and Tabasco pepper pests can be efficiently managed using IPM practices and pesticide application thresholds developed for bell peppers. (3) Transgenic or genetically-engineered tomato and pepper cultivars selected for resistance to the most important viruses might provide a key IPM component to reduce damage caused by begomoviruses and potyviruses.

**e.** **Description of research activity:** (1) Virus identification and distribution. A total of 260 leaf tissue samples will be collected from three geographical areas during the two consecutive cropping cycles of this year. Of these, 100 will be collected by EAP and 260 by FHIA, assuring that pepper, tomato and cucurbits are equally represented in number of samples. The symptoms and circumstances of occurrence of the problem will be recorded, including photographs, for the preparation of a field guide. Each sample will be tested by means of ELISA against a battery of viruses and by PCR for Geminivirus using specific primers. Personnel from UA will visit Honduras to provide *in situ* assistance on analytical procedures. Whitefly adults and nymphs will be collected and sent to Dr. J. Brown for biotyping. (2) Development of IPM system for insect pests of peppers. A scouting procedure will be developed to monitor whiteflies, mites and pepper weevil and determine the need for pesticide application using thresholds values that have been developed for bell peppers. Collaborating farmers will be guaranteed an income from the experimental area under IPM. The IPM strategy will also include the use of predatory mites for the management of phytophagous mites, control of potential hosts for whiteflies and viruses along the edges of the field, with special emphasis on the windward side, etc., etc. Low environmental impact alternatives to chemical pesticides will be screened, evaluating effectiveness, application methods and rates. The screening process will be conducted using bioassay techniques in the US and at Zamorano. Validation trials will be conducted in cooperation with farmers and the agroindustry. (3) Evaluation of transgenic, virus-resistant tomato and pepper cultivars. Full-length virus clones (DNA A and DNA B) for Pepper golden mosaic virus (PepGMV) will be obtained, assayed for infectivity, and their DNA sequence obtained. Infectious clones will serve as sources of viral genes for genetically engineered resistance employing pathogen-derived resistance and for initial challenge-inoculation screening of engineered plants, in advance of the field-testing stage.

f. **Justification:** Vegetables in general and tomatoes and peppers in particular constitute an important source of food and income for many Honduran and Central American farmers. Cucurbits are already one of the most important export crops. Among the most important limiting factors of these crops are plant virus diseases that are little understood and mismanaged; their vectors and other insect pests are also important adverse factors. Before rational management strategies can be implemented, it is necessary to determine the causes of the diseases and to identify the sources of inocula. Under year-round irrigated agriculture conditions viral diseases and insect pests become a much more important problem since there is not a real interruption of their biological cycles. Accurate virus identification and knowledge of the biological characteristics of each virus will permit for the first time the implementation of rationale control approaches that can be integrated in the context of a cropping system. Directed control through implementation of appropriate cultural practices and management of insect vector and direct pest populations will result in reduced application of hard insecticidal chemicals, thereby encouraging environmentally safer production practices in Honduras.

g. **Relationship to other CRSP activities:** This project had complementary efforts in Guatemala to determine the composition of plant viruses and whitefly vector in vegetable cropping systems.

h. **Progress to date:** ELISA and PCR hardware already exist in the laboratories of FHIA and EAP. Optimization of ELISA methods (Indirect, DAS-ELISA and DABI) and PCR methodologies has been accomplished collaboratively between Arizona and EAP. Universal PCR primers and methodologies for geminivirus detection and subsequent identification have been provided by the Arizona laboratory to EAP.

i. **Project outputs:** (1) Establishment of ELISA and PCR methodologies for detection and identification of important plant viruses at FHIA and EAP. (2) Strengthen collaborative interactions between scientists at FHIA, EAP, Purdue and Arizona. (3) Student thesis on identity and distribution of plant viruses in vegetable cropping systems (with emphasis on peppers, tomatoes) in the three specified regions of Honduras. (4) Scientific abstract, Disease Note, and/or article resulting from preliminary survey data. (5) Initial effort toward field guide and website entries of the most common virus diseases, to enable preliminary virus disease identification by farmers and technicians. (6) An IPM program for Jalapeño and Tabasco peppers. (7) First steps toward obtaining infectious begomovirus clones and constructing test transgene cassettes necessary for developing transgenic tomato and pepper cultivars with resistance to tomato and pepper-infecting begomoviruses.

**j.** **Projected impacts:** (1) First documentation of the most important vegetable crop-infecting plant viruses in Honduras that will allow for development of rationale management approaches based upon the accurate identification of viruses and knowledge of their associated biological characteristics. (2) Establishment of timely laboratory tools that permit serological and molecular identification of plant pathogens. (3) Training of personnel from the laboratories of FHIA, EAP and Del Valle at the University of Arizona. FHIA personnel will be trained at Arizona and at EAP and personnel from EAP will be trained at the Universidad Del Valle. In addition, two in-service training students from Zamorano attended Purdue University for 3 months and now are enrolled as full time graduate students. (4) Field guide of the most common virus diseases will enable preliminary virus disease identification by farmers and technicians toward rationale control strategies. (5) Reduction in the use of hard insecticidal chemicals. (6) Disease resistance in locally adapted tomato cultivars will enable farmers to control the targeted whitefly-transmitted virus diseases, thereby increasing crop productivity. This will result in more optimal use of fertilizer inputs per output, and will contribute to reduce pesticide use aimed at controlling the whitefly vector.

**k.** **Projected start:** September 29, 2001

**l.** **Projected completion:** September 28, 2004

**m.** **Projected person-months of scientist time per year**: 12 person-months

**n.** **Budget:** FHIA - $30,000 (FAS/GOH); Zamorano - $30,000 (FAS/GOH); U. of AZ - $36,040 (FAS/GOH); PURDUE - $13,000 (FAS/GOH)

## III.1 Evaluation of *Brassica* organic residues as soil biofumigants and solarization in broccoli and tomato.

**a.** **Scientists:** H. Carranza, L. Calderón, D. Dardón, M. Morales – ICTA; S. Weller - PURDUE

**b.** **Status:** Continuing activity

**c.** **Objectives:** (1) To determine if the utilization of crop residues as soil biofumigant has any beneficial effects on broccoli and tomato yields and quality; (2) To establish the effectiveness of biofumigation as a soil disease management tool; (3) To determine the effect of biofumigation on the soil fertility levels; (4) To establish the production costs and profitability of biofumigation in broccoli and tomato.

**d.** **Hypotheses:** (1) Biofumigation is an effective alternative to Methyl bromide for soil disinfestation purposes in broccoli and tomato grown in Guatemala; (2) Biofumigation is an agricultural practice that enhances the soil fertility and plant nutrition of broccoli and tomato speedlings.

e. **Description of research activities:** *Soil treatments*: The usage of organic residues as biofumigants is a proven technology generated by the University of Almería in Spain and it has shown great potential in results of studies conducted to search for viable options for using methyl bromide as a soil fumigant.

Completely randomized blocks with 4 treatments and 5 replicates will be established twice for each crop. Treatments in the broccoli plots will be: 1) broccoli residues at 5 kg per m2 incorporated 6 weeks before planting; 2) broccoli residues (5 kg/m2)+soil solarization for a period of six weeks; 3) soil solarization and 4) check plot, no treatment to the soil. The experimental units will be 6.5 X 5 m = 33m2. Treatments in the tomato plots will be: 1) tomato residues at 5 kg per m2 incorporated 6 weeks before planting; 2) tomato residues (5 kg/m2)+soil solarization for a period of six weeks; 3) soil solarization and 4) check plot, no treatment to the soil. The experimental units will be 6.5 X 5 m = 33m2. These trials will be done during both the dry and rainy seasons.

f. **Justification:** This research represents an important component of ICTA's activities in the "Protection of the Ozone Layer Project", as part of Guatemala's commitment to comply with the Montreal Protocol in finding options to the usage of methyl bromide in agricultural activities. The technology tested in this research bases its effectiveness on the releasal of gases produced by microorganisms acting upon the organic residues previously incorporated into the soil. The utilization of organic residues from Brassica and solanaceous plants has proven particularly effective against plant pathogenic microorganisms (fungi, bacteria and nematodes) as well as some weed species. According to previous research, the decomposition of Brassica crop residues causes the formation and releasal of methyl isothiocynate into the soil.

g. **Relationship to other CRSP research activities:** This study is complementary to other IPM activities carried out in melons, lettuce, carrots and cauliflower. If proven effective, this technology can be included in organic crop production, which has been targeted as a priority area, by AGEXPRONT, and other organizations in the expansion of horticultural exports being grown in Guatemala.

h. **Progress to date:** In broccoli and tomato initial results, from plots planted in 2001, show that biofumigation does indeed reduce weed densities, reduce incidence of soilborne pathogens, mainly Fusarium in tomatoes and clubroot in broccoli. Plants show increased vigor and leaf area, and yields are larger, earlier and more uniform.

i. **Projected outputs:** To offer the growers of Guatemala, soil biofumigation as an effective soil disinfestations alternative that will not only effectively control soilborne pathogens and weeds but will also improve the soil fertility in a economic and environmentally sound fashion.

**j.** **Projected impacts:** The adoption by growers of biofumigation would reduce the usage of methyl bromide in broccoli seedbed and fields. It would also reduce the usage of methyl bromide and other chemical methods in greenhouse speedling productions. Application of this technology would enhance the organic production of broccoli and tomato.

**k.** **Projected start:** July 2000

**l.** **Projected completion:** June 2003

**m.** **Projected person-months of scientist time per year:** 8 person-months

**n.** **Budget:** ICTA - $15,280 (IPM CRSP)

**IV.1 Establishment of a quality control pre-inspection process in the production and export of snow peas in Guatemala.**

**a.** **Scientists:** G. Sánchez, J.L. Sandoval – ICADA; G.H. Sullivan, S. Weller – PURDUE; L. Caniz - APHIS-IS/Guatemala

**b.** **Status:** Continuing research

**c.** **Objectives:** *Overall:* The overall objective of this project is to implement performance-tested IPM strategies and quality control program in snow peas, targeted to reduce the number of USDA interceptions due to pest infestations and unacceptable pesticide residues. The specific objectives are to: (1) Reduce the level of unacceptable pesticides residues in the export product. (2) Prevent future pest outbreaks such as the 1995 leafminer crisis. (3) To produce high quality snow peas which are safe to consumers and grown in a sustainable production system. (4) Demonstrate to the Guatemalan snow pea industry the advantages of a quality control program that will help ensure the country's future competitiveness in the snow pea export market. *Year 10 objective:* To finalize, in collaboration with PIPAA (AGEXPRONT´s Integrated program for the protection of the environment and agriculture) and APHIS, the implementation of a fully operational ICM program for snow peas in Guatemala. The IPM CRSP will generate the technical guidelines for the program while PIPAA will supervise and certify snow peas produced under such guidelines.

**d.** **Hypothesis:** The implementation of a quality control program (pre-inspection) in the production, packing and export of snow peas will reduce the number of interceptions conducted by USDA authorities at the point of entry to the US markets.

**e.** **Description of research activity:** Based on the protocols designed for the evaluation of Integrated Crop Management snow pea plots, a production and post-harvest quality control (pre-inspection) program will be implemented. Specific production and post-harvest guidelines will be developed and implemented by growers and exporters alike.

Trained inspectors, who will be in charge of monitoring and supervising the production and packing technology utilized in Guatemala, will supervise the enforcement of these guidelines. These inspectors will have previously received adequate training through specific seminars and courses. It is expected that by the end of the 2002 growing season, over 90% of contract-grown and packer-grown snow peas will be produced under the ICM protocol guidelines.

**f.** **Justification:** The future sustainability and competitiveness of Guatemala as a non-traditional crop exporter may depend on the implementation of sound control programs that ensure the quality of the export product. Presently, Guatemala is the country in Central America with the highest number of interceptions at the port of entry to US markets. If corrective measures, such as the quality control program described in this proposal, are not taken, the country's future as a fresh produce exporter may be in jeopardy.

**g.** **Relationship to other CRSP research activities:** This project is intimately linked with other activities at the site, including research in non-chemical approaches to manage snow pea pests, its results to be incorporated to the pre-inspection program. Local and US IPM CRSP collaborators, including ICADA, ICTA, Purdue University and Universidad Del Valle are conducting the aforementioned research.

**h.** **Progress to date:** The pre-inspection leading team has been organized, and it includes representatives from the private sector, AGEXPRONT, IPM CRSP, APHIS-IS, and ICTA. Initial collaborating packing plants include FRUTESA, EXOTIC, S.A and San Lucas Agroexport. PIPAA and the IPM-CRSP are developing the training manuals for inspectors and field ICM guidelines for growers.

**i.** **Projected outputs:** An effective pre-inspection program for snow peas that will guarantee (1) the quality of the product to the final consumer and (2) the sustainability of the snow pea industry in Guatemala.

**j.** **Projected impacts:** (1) The future incorporation into the program of the great majority of Guatemalan snow pea exporters. (2) Elimination of the "automatic detention" status at the port of entry for Guatemalan snow pea exporters.

k. **Projected start:** August 1998

**l.** **Projected completion:** October 2003

**m.** **Projected person-months of scientist time per year:** 12 person-months

**n.** **Budget:** ICADA/Sanchez - $5,235 (IPM CRSP); ICADA/APHIS - $19,250 (FAS/GOG)

## IV.2 Telemetric measurement of the climatic factors involved in the populations dynamics of leaf miners (*Liriomyza huidobrensis*) and *Ascochyta pisi* in snow peas.

a. **Scientists:** L. Calderón, D. Dardón, F. Solis- ICTA; S. Weller - PURDUE

b. **Status:** Continuing activity

c. **Objectives:** To develop a prediction model for Ascochyta leaf and pod blight and leaf miner populations in snow peas, based on models derived from measurements of temperature, relative humidity and rainfall.

d. **Hypothesis:** Mathematical models, developed by monitoring key climatic factors such as rainfall, relative humidity and temperature, can be utilized to predict the populations of leaf miners and dissemination of Ascochyta blight in snow peas in Guatemala.

e. **Description of research activity:** A telemetric computing equipment (model MDAgroet ET-A 760) obtained by ICTA through the National Council for Science and Technology will be utilized to measure and record daily fluctuations in temperature, relative humidity and rainfall. These parameters will be contrasted to leaf miner adult and larval population samplings and Ascochyta severity indexes in snow peas. As a result, a mathematical model will be developed, to be used in the prediction of suitable environmental conditions for the reproduction of leaf miners and growth and dissemination of *Ascochyta pisi*.

f. **Justification:** This research represents an important component of ICTA's activities as it represents the first attempt in Guatemala to develop mathematical models that can be used in the prediction of pest outbreaks. As it is well known these models play a key role in other parts in the world, in the management of important agricultural pests.

g. **Relationship to other CRSP research activities:** This study is complementary to other IPM activities carried out snow peas, as it can provide key information regarding the utilization of specific management practices such as chemical or cultural control for leaf miners and Ascochyta blight.

h. **Progress to date:** Developed preliminary models for Ascochyta blight which indicate a strong correlation between predicted and real measurements of Ascochyta leaf and pod blight. These correlations are based mainly on relative humidity, and rainfall. In the case of leaf miners preliminary models show a strong positive correlation between forecasted and real populations during the rainy season. During the dry season the mathematical models are capable of adequately predicting the numbers of leaf miner eggs, but fail to correctly estimate numbers of adult and larval populations.

i. **Projected outputs:** (1) A mathematical model that can be used to predict the most favorable conditions for the increase of leaf miner populations in snow peas; (2) A mathematical model that can be used to predict the most suitable conditions for the reproduction and dissemination of *Ascochyta pisi*, causal agent of Ascochyta blight in snow peas.

j. **Projected impacts:** To provide growers with a warning system that can be utilized rationally apply the necessary management controls for leaf miners and Ascochyta blight in snow peas.

k. **Projected start:** October 2001

l. **Projected completion:** November 2003

m. **Projected person-months of scientist time per year:** 8 person-months

n. **Budget:** ICTA - $9,900 (IPM CRSP)

## IV. 3 Identification of factors responsible for limiting melon production in Southern Honduras.

a. **Scientists:** D.T. Krigsvold, J.M. Rivera, J.C. Melgar – FHIA; R. Martyn– PURDUE; G. Sánchez - ICADA

b. **Status:** New activity

c. **Objectives:** *Overall:* This activity is envisioned as a three year project and to be carried out in the melon growing areas of the southern "departamentos" of Valle and Choluteca, Honduras, where recurrent severe losses of melon production have occurred since 1994. The objective of the project is to determine the cause (s) of the vine "collapse" syndrome of melon plants that occurs late in the season, generally at or near time of fruit maturation, particularly during the first production cycle (November-January).
*Year 10:* Two consecutive production cycles of melons are normally grown in Honduras: November- January and January-March. Data will be collected and analyzed during the first year and will be used to refine the second year's experimental protocol. Additionally, treatments that appear promising for control will be tested in collaborators fields. In the third year a final integrated crop management (ICM) package will be validated under commercial field conditions.

d. **Hypotheses:** (1) Production of melon seedlings in multi-cell trays results in transplants with poorly developed root systems which are worsen by field irrigation regimes commonly practiced. These result in severe morphological and functional abnormalities of the root systems that lead to a) stress-induced susceptibility of the plants to an assortment of fungal soilborne diseases, and b) eventual vine "collapse" and plant death. Thus, changing the manner in which melons are grown might alleviate or reduce the amount of vine collapse late in the season when the plants are under heat, drought, and fruit stress. (2) Many years of continuous mono-cropping with melons and the intensive use of plant protection agrichemicals have resulted in changes in the soil populations of natural microfauna and microflora that contribute in keeping soilborne plant pathogens at low levels. Thus, if these populations could be brought back to their original levels in the soil and the rhizosphere it might alleviate or reduce vine collapse.

**e.** **Description of research activity:** In order to test the first hypothesis, a study will be established in three different fields (with a history of "Collapse") of collaborating growers. Combinations of each of the following factors will be evaluated in an appropriate experimental design consisting of four treatments: Soil sterilization (with *vs* w/o Methyl Bromide), irrigation regime, and seeding method (transplants grown in customary trays *vs* direct seeding and/or seed-bed produced plants). All three fields will be managed according to standard cropping practices. Data collected will include seedling characteristics at time of transplanting (root and shoot development), vine "collapse" incidence, potential pathogens isolated from roots, and marketable fruit yield.

To test the second hypothesis, two different field experiments will be conducted using different approaches. One experiment is aimed at improving the general biological condition of the soil *per se* by means of application of treatments resulting from combining soil solarization and the incorporation of cover crops into the soil as comparison to conventional cropping (including MeBr treatment). The other experiment is aimed at improving the general health of the plants by treatments of both individual and combined use of the mycorhyizal fungus *Glomus intraradices* (BuRize®), the antagonistic fungus *Trichoderma harzianum* (Root Shield or another suitable) and the protein Harpin (Messenger®). Each test will be conducted in two different fields.

**f.** **Justification:** Melons are the third most economically important export-oriented agricultural crop in Honduras, after coffee and bananas. In addition, the crop is an important source of employment and economic activity in the areas of the Southern region of the country where the crop is concentrated. Unfortunately, over the last 8 years there has been a recurring problem of vine "collapse" late in the season, generally at or near fruit maturation, which has led to yield losses of up to 50 percent in some years. This generally has been attributed to soilborne fungal pathogens. During this time specialists from different institutions, including FHIA, Zamorano, Chiquita, DOLE, PETOSEED, and Texas A&M University, have been brought in to observe the problem in the field. Numerous potential pathogenic fungi have been isolated from roots of diseased plants obtained from different fields and different varieties, including species of *Fusarium*, *Pythium*, *Sclerotium*, *Rhizoctonia*. As a result, it has been difficult, if not impossible to attribute the exact cause of the problem. In addition, there is circumstantial evidence (FHIA and Purdue) that might suggest the problem may be related to changes in production practices that have occurred in the melon industry over the last two decades, particularly in the industry's wide use of transplants as compared to direct seeding in the past. In fact, field observations show that the transplants produced locally in trays have malformed root systems and that the watering regimes applied in the field (usually very short and frequent cycles) may also be contributing to the problem. Finally, most fields used for melon production in Southern Honduras have been cropped with melons for the last 12-15 years, usually twice a year, and without proper rotation. Additionally, the intensive use of conventional synthetic chemicals in soils that are naturally poor in organic matter to control pests has had a negative effect on the beneficial soil microflora. This no doubt has led to impoverishment of the soil biota that under normal conditions would also contribute to keeping soilborne pathogens under control. Determination of the precise cause of the "collapse" of melon vines and of the most appropriate measures to prevent it will assure the sustainability of this important crop in the Southern region of Honduras.

g. **Relationship to other CRSP research activities at the site:** This is a new activity to be proposed for implementation by FHIA and Purdue University. It is related to another IPM-CRSP Year 9 project on virus diseases of melons, tomato, and peppers in the two most important horticulture areas of Honduras. This project is conducted between, Zamorano, FHIA, University of Arizona and Purdue University.

h. **Progress to date:** New activity

i. **Projected outputs:** (1) A diagnosis of the pathological and/or cultural practices important in the manifestation of the vine "collapse" syndrome of melons in Southern Honduras; (2) Recommendations for management of vine "collapse"; (3) Scientific papers amenable for publication in refereed scientific journals.

j. **Projected Impacts:** (1) Recovery of the melon production industry in Honduras to economically-acceptable production levels; (2) A significant contribution to the recovery of the local and national economy; (3) Introduction into the melon production operations of "clean" cropping practices designed to assure sustainability of the crop as an agricultural activity in the southern region of Honduras.

k. **Projected start:** October 2002

l. **Projected completion:** September 2004

m. **Projected person-months of scientist time per year:** 3 person-months

n. **Budget:** PURDUE $3,250 (IPM CRSP); FHIA $17,500 (IPM CRSP)

**INTEGRATED PEST MANAGEMENT -- COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), CENTRAL AMERICAN SITES IN GUATEMALA AND HONDURAS**

| ACTIVITY | | SCIENTISTS | BUDGET ($) |
|---|---|---|---|
| **SOCIOECONOMIC, MARKETING, AND POLICY ANALYSIS** | | | |
| I.1 | Institutionalize performance standards for postharvest handling and regulatory compliance (including food safety) for achieving sustainable NTAE program development in Central America | G. Sullivan, J. Julian, S. Weller - Purdue; G. Sanchez - ICADA | Purdue $42,831 |
| I.2 | Assessment of the impact on rural health of IPM CRSP technology adoption in the NTAE snow pea production system | G. Sanchez - ICADA; L. Asturias - Estudio 1360; S. Hamilton - Virginia Tech | Purdue/ICADA $11,359 |
| I.3 | Economic and socioeconomic impact assessment of IPM and nontraditional crop production strategies on small farm households in Guatemala | S. Hamilton - Virginia Tech; G. Sanchez - ICADA; G. Sullivan - Purdue; L. Asturias de Barrios - Estudio 1360 | VPI/Hamilton $19,155 ICADA/Hamilton $15,730 |
| **ASSESSMENT OF ALTERNATIVE CROPPING SYSTEMS INCLUDING BIORATIONAL AND ORGANIC APPROACHES** | | | |
| II.1 | Improved IPM production strategies for integration into prototype preinspection programs in NTAE crops | S. Weller, G. Sullivan - Purdue; G. Sanchez - UVG; C. Mayen (Guatemalan Graduate Student) - Purdue | Purdue $33,415 ICADA/Weller $13,424 |
| II.3 | Assessment of insect pests and diseases, integrated pest management studies and development of PRSV-resistant plants in "solo-type" Hawaiian papayas | G. Sanchez - ICADA; M. Palmieri - UVG; S. Weller, G. Sullivan - Purdue; L. Calderon, D. Dardon - ICTA; W. Parrott, M. Deom - U. of Georgia | ICADA/Sanchez $20,350 ICADA/UVG $13,750 U. of GA $ 3,250 |
| II.6 | Identification, distribution, epidemiology, and management of viral plant pathogens and insects that threaten solanaceous and cucurbit crop production in Honduras | D.T. Krigsvold, J.M. Rivera, J.C. Melgar, H.R. Espinoza - FHIA; A. Rueda, M. Mercedes Roca de Doyle, E. Aguilar - Zamorano; R. Martyn - Purdue; G. Sullivan, G. Sanchez (CRSP Administration); J. Brown, Arizona | FHIA $30,000 Zamorano $30,000 U. of AZ $36,040 Purdue $13,000 |

| | | | |
|---|---|---|---|
| **BIOLOGICAL CONTROL TECHNIQUES** | | | |
| III.1 | Evaluation of *Brassica*organic residues as soil biofumigants and solarization in broccoli and tomato | H. Carranza, L. Calderon, D. Dardon, M. Morales - ICTA; S. Weller - Purdue | ICTA<br>$15,280 |
| **STRATEGICALLY TARGETED DISEASE AND INSECT CONTROL** | | | |
| IV.1 | Establishment of a quality control pre-inspection process in the production and export on snow peas in Guatemala | G. Sanchez, J.L. Sandoval - ICADA; G.H. Sullivan, S. Weller - Purdue; L. Caniz - APHIS-IS/Guatemala | ICADA/Sanchez<br>$ 5,235<br>ICADA/APHIS<br>$19,250 |
| IV.2 | Telemetric measurement of the climatic factors involved in the populations dynamic of leaf miners (*Liriomyza huidobrensis*) and *Ascochyta pisi* in snow peas | L. Calderon, D. Dardon, F. Solis - ICTA; S. Weller - Purdue | ICTA<br>$ 9.900 |
| IV.3 | Identification of factors responsible for limiting melon production in Southern Honduras | D.T. Krigsvold, J.M. Rivera, J.C. Melgar - FHIA; R. Martyn - Purdue; G. Sanchez - ICADA | Purdue<br>$ 3,250<br>FHIA<br>$17,500 |

# Year Ten IPM CRSP Annual Workplan: Ecuador

In year 10, the IPM CRSP will begin its sixth year of research in Ecuador. Activities focus on potato-based systems in the Sierra, plantain-based systems in the coastal region, and mixed coffee-plantain system and Andean fruits at intermediate elevations. The PIPM approach is being followed in which pest management problems and constraints are being diagnosed through crop/pest monitoring, targeted participatory appraisal activities, and focus group activities are being undertaken aimed at gender issues. Multi-disciplinary on-farm pest management experiments for potatoes are being conducted in the Carchi region as well as farther south, complemented by a limited amount of laboratory, greenhouse, and micro-plot experiments on station at Santa Catalina. Special efforts are being made at validating and diffusing IPM approaches already developed on the CRSP, working with the validation and technology transfer units of INIAP, the principal government institution for research and technology transfer. The plantain research is virtually the first research that has addressed pest problems on plantain (as opposed to trying to transfer results from banana). It has become critically important now that plantain has become an important export crop in Ecuador because the only alternatives up to now have involved heavy pesticide applications for insects, diseases, and nematodes. The Andean fruit experiments focus on non-traditional export crops with strong export potential. Socioeconomic analyses address three primary issues: impact assessment and adoption, with a significant gender component.

Research activities are planned and conducted in a multidisciplinary fashion. Ecuador, CIP, and U.S. scientists review progress and plan future activities in joint meetings with all disciplines contributing to the discussion. Biological scientists assist the social scientists by collecting cost and return data to be used in impact assessment. The Site Coordinator, located at the Pichlingue station near Quevedo on the coast, works with the assistant coordinator for the Sierra, located at the Santa Catalina Experiment Station south of Quito, coordinate the day-to-day research activities. They integrate undergraduate student theses into the research where ever possible to help institutionalize knowledge and interest in IPM. International and U.S. institutions contributing to the IPM CRSP program in Ecuador include CIP/Lima, Ohio State, Georgia, Florida A&M, and Virginia Tech.

## II. Multidisciplinary On-Farm Pest Management Experiments

### II.2. Development of biological control methods for two major potato pests in Ecuador. The Andean Potato Weevil *Premnotrypes vorax* and the Central America Tuber Moth *Tecia solanivora.*

a) **Scientist:** Jovanny Suquillo, Patricio Gallegos- INIAP; Azis Lagnaoui-CIP.

b) **Colaborating scientists:** R. Williams, Ohio State University.

c) **Status:** Continuing activity.

d) **Objetives:** (1) Reduce losses caused by potato weevil and the Central America tuber moth; (2) Increase the efficiency of baculovirus using a chitin inhibitor to control ***Tecia*** under storage conditions (3) Lower risk of health deterioration of farmers and consumers through biological control and application of low toxicity insecticides.

**Objectives for year 10**: Develop cultural alternatives to control Central American potato moth, ***Tecia solanivora***.

**e) Hypothesis:** (1) Season or ways of hilling do not reduce the damage of the Central American moth on potato crop; (2) The use of chitin inhibitors does not improve the baculovirus control efficiency over the crop.

**f) Description of research activity**:

**Field trial:** Treatments will consist of a combination of three hilling dates (in advance of those that farmers normally do) and two methods of hilling (normal and crossed). The trial will be set under a complete block design with four repetitions. The experimental unit will be 8 rows of 10 m length. Variables to evaluate will be tuber percentage of damage and number of larvae at 110, 120, 130, 140, 150 days of the crop and at harvest. Percentage of damage and number of larvae and pupae will be evaluate on tubers stored during 30 and 45 days after harvest to know Tecia´s population variability under storage.

***Tecia*** management in storage conditions. The chitin inhibitor LUFENURON will be used to study the effectiveness of the baculovirus. Bioassays will be conducted in advance, to determine the response of larvae of the first exposure to the baculovirus and the chitin inhibitor. Then the LD30 (lethal dose to 30% of larvae) will be applied. A combination of these results (concentrations) will constitute the treatments for the baculovirus effectiveness trial. Then we will test 4 treatments with 2 controls, one only baculovirus and another without any treatment. Tubers will be soaked on every treatment and then placed in wooden boxes covered with plastic mesh and containing adult male and female moths. A completely randomized design with a $2^2 + 2$ factorial arrangement with six repetitions will be used. The experimental unit will consist of plastic containers with 3 tubers each; three of them will be evaluated 30 days and the other 3 at 45 days after experimental set up. Larval mortality, percent of infected larvae, prepupae recuperation, percentage and intensity of tuber damage will be evaluation parameters.

**h) Justification:** The potato weevil and the Central America tuber moth are the most important pests of potato in Ecuador at the field as well as in storage. Farmers use highly toxic compounds to control these pests. Continuous and excessive application have not diminished tuber damage on the field. In these experiments we expect to replace these compounds by low toxic insecticides and implement biological control for these pests. The method of control developed so far will complement each other and will offer high-quality tubers at harvest. Risk of toxicity for farmers will be low. Farmers use highly toxic insecticides and store tubers within their homes. Therefore the health risk for them is high.

The baculovirus has shown variable effects on the control of this pest, this has prevented its adoption. The use of chitin inhibitors may reinforce the efficacy and stability of the baculovirus on potatoes stored as seed. There are no studies about virus potency through addition of chitin inhibitors.

h) **Progress to date:**

Differences in tuber damage have been found to be related to tuber depth in soil. Baculovirus mass production and its efficiency under storage conditions have as well been determine. On the other hand, it is known that chitin inhibitors were specifically developed for lepidoptera.

i) **Relationship with other CRSP activities:** This work will offer control elements to develop integrated management of this pest and will be link with transfer activities, and with IPM practices under development for potato weevil.

j) **Project Output:** (1) Efficient and low toxic control technologies; (2) A better control strategy for ***Tecia***; (3) Better knowledge of biology and management of ***Tecia*** at field level; (4) An MSc thesis (5) Publications about management of potato weevil and ***Tecia*** for farmer use.

i) **Project Impacts:** Cheaper and low toxic control technologies that may be useful for other pests and crops.

j) **Project Start:** September 1998.

k) **Project Completion**: September 2004.

l) **Project person/months per year**: 5

m) **Budget:** INIAP/CIP – $ 20,988; Ohio State – $ 20,336

### II.3.3. Developing IPM programs for naranjilla (*Solanum quitoence*) in Ecuador

**a.** **Scientists:** J. Ochoa, P. Gallegos, M. Insuasti – INIAP; M. Ellis, R. Williams - Ohio State University. **Collaborative scientists**: A. Martínez, J. León - INIAP.

**b.** **Status**: Continuing

**c.** **Objectives:**

**Overall:** (1) Develop pest control methods for the major pests of Andean fruit crops. (2) Integrate control methods into IPM programs for the main Andean fruit pests. (3) Develop technical and scientific publications from the results obtained in these studies. (4) Disseminate research results and IPM programs through the use of field days bulletins and other educational forums and materials.

**Current year for Naranjilla:** (1) Evaluate various insect traps for naranjilla borer adult moths. (2) Develop rearing systems in order to obtain virgin females, and compare attraction of virgin females to artificial pheromones in order to learn efficacy of lures in monitoring. (3) Develop light traps for use on the farm which do not use electric power sources. (4) Determine the efficacy of current disease management technology for the control of the major diseases of naranjilla in the Pastaza valley. (5) Screen for resistance to *F. oxysporum* in the L*asiocarpa* family.

**d.** **Hypothesis:** (1) Traps differ in their efficacy for capturing naranjilla borer adult moth. (2) Artificial pheromones differ in their efficacy to attract males of the species. By rearing virgin females, we will discover the power of the real virgin attractant, and be able to compare it to the artificial lures. (3) Relatively inexpensive light traps can be developed for use on the farm. (4) Current disease management technology is effective for control of the major naranjilla diseases. (5) Resistance to *F. oxysporum* is available in the *Lasioarpa* family.

**e.** **Description of research activities:** Traps consisting of pheromones and virgin females will be evaluated. Traps will be constructed using a plastic container in which two windows will be opened 6 cm from the bottom. In the base of the trap soap solution will be placed. The pheromones and virgin females will be hung in the central part of trap. Ten traps of each type will be evaluated in at least two locations. Light traps will be designed to use kerosene, gas, and/or use a battery source. These traps will be placed in the dark on a plastic surface covered with a sticky substance. Captured adults will be quantified the next morning. Traps will be placed in commercial plantings as the fruit begins to mature. Field trials using the naranjilla varieties “Agria”, “Peluda”, “Bolona”, “Baeza”, “Baeza Roja”; the hybrids “Puyo” and “Palora” and an accession of cocona (*Solanum sessiliflorum*) will be established to evaluate currently available methods for disease control of naranjilla vascular wilt (*F. oxysporum*), Phythophthora blight (*Phytophthora infestans*) anthracnose (*Colletotrichum gloeosporioides*) and bacterial wilt (*Pseudomonas solanacearum*). The experiment will be conducted in two secondary forest plots with different histories of crop management. In one of the plots, naranjilla will have never been cultivated whereas in the other plot, naranjilla will have been grown three years ago. Management of naranjilla vascular wilt will depend primarily on sanitation. Before transplanting, plants will be treated with Carbendazim to ensure pathogen free planting material. Rotating protective and systemic fungicides according to weather conditions and disease severity will control *Phytophthora* blight. Systemic fungicides to be applied are Metalaxil, Propanocarb and Fosetil-Al and protective fungicides are Mancozeb, Chlorothalonil and Copper. Anthracnose control will be based on applications of Difeconazole, Vitertanol, Exaconazole and copper fungicides. Bacterial wilt will be managed by eradicating diseased plants, sterilizing soil at infection sites and with treatments of the antibiotic Kusagumizin. A check using standard farmer practices will be also included. Resistance *to F. oxysporum*, causal agent of NVW, will be evaluated in accessions from the lasiocarpa section of the *solanaceae* family. An INIAP collection of the Lasiocarpa section will be evaluated for resistance by inoculating plants with isolates of *F. oxysporum*. Appropriate plant age for inoculation and inoculation methods will be established prior to initiating the evaluation. Plants will be evaluated with different inoculation techniques at 15, 30 and 45 days after germination.

f. **Justification:** Former surveys show that naranjilla borer is an important pest and can eliminate naranjilla profitability. A recent publication from Colombia reports that the naranjilla borer also attacks other crops. Of particular concern is that these borers also attack the common tomato. If this strain gets to Ecuador, it could result in serious economic losses. Chemicals are currently applied to control fruit borer. However, control methods using insect behavior can effectively replace chemical control and significantly reduce health risks to farmers and consumers. Surveys of naranjilla diseases have been carried out during year six and seven of the IPM/CRSP project in Ecuador. In these surveys naranjilla vascular wilt, *Phytophthora* blight, anthracnose and bacterial wilt were found to be the main constraints to naranjilla production in Ecuador. Epidemics of these diseases have resulted in decreased production or elimination of common naranjilla in the Pastaza valley. Similar disease epidemics are also occurring in new naranjilla production areas. Common naranjilla is very susceptible to these diseases and most farmers currently believe that production of common naranjilla is not profitable. Evaluation of the current technology available to control naranjilla diseases is very important in order to establish the real potential of common naranjilla as well as identify problems that require further research.

g. **Relationship to other CRSP activities:** These studies are a continuation of surveys and research activities conducted in years six, seven and eight. Similarly, anthracnose management in naranjilla can also be easily transferable to anthracnose management in other tropical fruit crops. Evaluation of current pest management technologies for naranjilla diseases can also be a model for other crops. Biological control of *Phyllophaga* spp. And the use of insect trapping technology for naranjilla fruit borer can also be applied to other Andean fruit crops.

h. **Progress to date:** At present, it is known that a pheromone from a closely related *Neocelinoides* moth has efficient levels of *Neocelinoides* attraction in eastern Ecuador. Flight behavior of *Neocelinoides* is also known which will help in defining time and location of trap lights. Surveys of major diseases of naranjilla have been conducted in years six, seven and eight of the IPS/CRSP. Similarly, pathogenicity and pathogen transmission of *F. oxysporum* causing naranjilla vascular wilt have also been determined. For mite studies, evaluation methods and a scale to assess damage have been developed during the previous year and for *Phyllophaga sp.* One alternative control has already been developed which will be integrated in an IPM program.

i. **Projected Outputs:** The profitability of common naranjilla cultivation using current disease management technology will be determined. Resistance in the *Lasiocarpa* section to *F. oxysporum* will allow us to improve resistance in naranjilla by using resistance varieties as rootstocks. These varieties could also be used in breeding programs.

j. **Projected Impacts:** Results from these studies will eventually lead to the implementation of IPM programs for naranjilla in Ecuador. In addition to providing cash crops for growers from local sales, increased production of these crops could lead to exportation markets and increased profitability to growers in Ecuador and neighboring countries such as Colombia.

**k.** **Projected Start**: October 2002

**l.** **Completion**: September 2003

**m.** **Person month per year**: 8

**n.** **Budget for year 10:** INIAP – $ 13,970; Ohio State – $ 3,780

## II.3. Developing IPM programs for Andean fruits in Ecuador

### II.3.6. Developing IPM programs for tree tomato *(Solanum betaceum)* in Ecuador

**a.** **Principal investigators:** J. Ochoa, P. Gallegos, M. Insuasti – INIAP; M. Ellis, R. Williams - Ohio State University. **Collaborative scientists**: A. Martínez, J. León – INIAP.

**b.** **Status**: Continuing

**c.** **Objectives**:

**Overall:** (1) Develop pest control methods for the major pests of Andean fruit crops. (2) Integrate control methods into IPM programs for the main Andean fruit pests. (3) Develop technical and scientific publications from the results obtained in these studies. (4) Disseminate research results and IPM programs through the use of field days bulletins and other educational forums and materials.

**Current year:** (1) Identify aphid species that transmit viruses to tree tomato. (2) Study virus transmission and determine the influence of fluctuating population of aphids on epidemics of tree tomato viruses. (3) Evaluate reactions of tree tomato varieties to the most important virus diseases. (4) Determine the efficacy of fungicides and cultural practices for control anthracnose fruit rot in tree tomato.

**d.** **Hypothesis:** (1) The aphid species transmitting viruses to tree tomato differ from those transmitting viruses in other fruit crops. (2) Fluctuating aphid population will affect the efficacy of virus transmission in tree tomato. (3) Tree tomato varieties react differentially to the most important tree tomato viruses. (4) Cultural practices combined with fungicide applications are effective in controlling anthracnose in tree tomato.

**e.** **Description of research activities:** Aphids will be collected in the most important tree tomato production regions. Aphids will be reared on young virus free tree tomato plants. Individual progenies will be multiplied in order to reduce variability among individuals.

Aphids will be classified using taxonomical manuals. For more detailed identification, representative aphid samples will be sent to specialized taxonomical Institutes. Efficiency of aphid species transmitting viruses will be evaluated. The effects of fluctuating of aphid populations on tree tomato virus epidemics will be also studied. The most efficient aphid species for virus transmission will be used to transmit viruses in order to study the reaction of tree tomato varieties to the most important viruses. Cultural practices combined with fungicide applications will be evaluated at two locations where anthracnose fruit rot is a serious constraint of tree tomato production. The effect of plant density, sanitation and fungicide application will be evaluated. Plant density treatments will consist of the standard farmer plant density and plantings with reduced plant density. Reduced plant density should result in increased air circulation. Sanitation will consist in collecting and burring diseased fruits prior to initiation of fungal sporulation. These cultural treatments will be combined with applications of the fungicides Difeconazole, Vitertanol, Exaconazole, Azoxistrobin and Metalsulfoxilate. These fungicides provided effective control of *C. gloeosporioides* in in-vitro tests. Fungicide application timing will be determined by weather conditions and disease incidence. Fruit yield and anthracnose incidence will be evaluated. An economic analysis of treatments will be also conducted.

f. **Justification:** Virus diseases cause serious losses in tree tomato, especially in the dry central valleys where aphid populations are high. Fruit yield losses can reach 50%. Few etiological and epidemiological studies have been conducted on tree tomato viruses. Aphid species and efficacy of aphid virus transmission have not been studied. Similarly, the reaction of tree tomato varieties to the main viruses is also unknown. Knowledge of these epidemiological aspects is important in order to develop management strategies for tree tomato virus diseases. Anthracnose is the main constrain of tree tomato cultivation in the warm, humid areas of Ecuador. Farmers in some areas have abandoned tree tomato cultivation due to this disease. Control of anthracnose in these areas has not been possible even with multiple applications of fungicide. Farmers do not understand the importance of sanitation on anthracnose epidemics. Therefore, it is important to integrate cultural practices such as sanitation with the timely application of fungicides in order to control anthracnose in tree tomato.

g. **Relationship to other CRSP activities:** Similarly, anthracnose management in three tomato and naranjilla can also be easily transferable to anthracnose management in other tropical fruit crops. Knowledge on the etiological and epidemiological of tree tomato viruses will be useful for other solanaseous crops in the region.

h. **Progress to date:** At present, it is known that a pheromone from a closely related *Neocelinoides* moth has efficient levels of *Neocelinoides* attraction in eastern Ecuador. Flight behavior of *Neocelinoides* is also known which will help in defining time and location of traplights. Surveys of major diseases of tree tomato have been conducted in years six, seven and eight of the IPS/CRSP. Similarly, fungicide efficacy and plant disease resistance studies are being conducted for anthracnose in tree tomato. Characterization of tree tomato viruses through pathogenicity and ELISA tests is also in progress. For mite studies, evaluation methods and a scale to assess damage have been developed during the previous year and for *Phyllophaga sp.* one alternative control has already been developed which will be integrated in an IPM program.

**i.** **Projected Outputs:** Epidemiological aspects of viruses associated with tree tomato and information on aphid transmission will be obtained. Information about resistance of tree tomato varieties to the main viruses will be also obtained.

**j.** **Projected Impacts:** Results from these studies will eventually lead to the implementation of IPM programs for tree tomato in Ecuador. In addition to providing cash crops for growers from local sales, increased production of these crops could lead to exportation markets and increased profitability to growers in Ecuador and neighboring countries such as Colombia.

**k.** **Project Start**: October 2001

**l.** **Project completion**: September 2003

**m.** **Person month per year**: 8

**n.** **Budget**: INIAP – $ 9,020; Ohio State – $ 3,780

## II.4. Development of IPM Programs for Plantain Systems in Ecuador

**a.** **Principal investigators:** C. Suárez-Capello, J. Cedeño, I. Carranza - INIAP; R. Williams, M. Ellis – Ohio State University; J. Alwang, G. Norton, C. Harris – Virginia Tech. **Collaborative scientists:** K. Solis – INIAP; Wills Flowers Florida A & M.

**b.** **Status**: Continuing activity

**c.** **Objectives**: (1) Evaluate under on-farm conditions, integrated pest and disease management strategies developed for plantain; (2) Evaluate the effects of continuous applications of sanitary practices on the incidence of the most common insects, nematode pests and Black Sigatoka disease on plantain.

**d.** **Objective for year 10**: (3) to develop strategies and methods to transfer technology developed under this project thus far to farmers and extension agents.

**e.** **Hypothesis:** (1) The application of improved agronomic practices will help reduce the impact of diseases and pests in plantain monoculture systems in western Ecuador**;** (2) Economic benefits of IPM practices developed under this project will be evident from data collected from the second harvest of research plots; and (3) Working with farmers on plots where the effects of different treatments are evident will help in designing instruments for transfer of IPM technologies.

**f.** **Description of research activities:** This activity will benefit from ongoing trials set to compare the effect of management programs to rehabilitate plantain plantations and to establish new plantations. In the rehabilitation activity: four treatments compare practices in use by farmers (minimum level) with two levels of IPM, one combined with and the other one without chemicals to control Black Sigatoka, weevils and nematodes. The fourth one is that recommended by the export companies. Treatments are combined in a complete block design with four replicates. Three of them will be maintained during year 10. New establishment of a plantation: in this case, a new plantation has been planted to compare two densities and two designs (spatial arrangement of plants within each plot). A split-plot design with four replicates will be considered for data analysis. In both cases, yield per treatment will be related to disease and pest incidence and severity, and to the cost/benefit ratio. Interactions with farmers and research scientists under direction of a social scientist will allow the design of methods and instruments to teach farmers IPM concepts and the use of the technologies developed. The acceptance of the instruments developed will be tested with groups of farmers of different conditions as described in the activity "gender".

**g.** During year ten, further research will be carried out to confirm that ***Radopholus similes***, the most damaging nematode in *Musa spp*. is really not present in the research area. Samples will be taken from different places of the experimental site and from different plots within the farm and screened for nematode type and genus.

**h.** **Justification**: Farmers need technical information to allow them to decide either to rehabilitate or to replant their plantations. The research carried out by the IPM-CRSP project during three consecutive years is providing the first scientific evidence to support such decisions. In addition, the establishment of IPM programs is urgently needed in order to prevent the area getting into the pesticide culture of bananas due to pressure from pests and diseases. It is well known that traditional means used by extension agents to transfer technologies in agriculture are inefficient and slow; therefore new methods and alternative instruments are required.

**i.** **Relationship to other CRSP activities**: This is the only project in the CRSP that deals with plantain. Results and research methods from this project will be directly applicable to other activities and projects in Ecuador. Some of the results from this trial will be tested in other activities within the same program.

**j.** **Progress to date:** Three cycles of harvest are showing differences between treatments. Leaf surgery combined with fungicides is showing good efficiency in reducing Black Sigatoka, even when the spraying period was increased to 45 days. The whole packet of IPM practices being applied in these treatments is showing an effect on the number, weight and quality of the fruit, making it more suitable for exportation. The dwarf variety used on the new plantation has shown more susceptible to Black Sigatoka and virus diseases and therefore we will not continue research with it. For new plantations a combination of high density planting with IPM management will reduce effects of Black Sigatoka on yield. The seasonal presence on the crops of different insect pests has been established, as well as the natural enemies that may potentially be used to control them.

Some components of IPM package are subject of different activities within this project for adjustment.

**k.** **Projected outputs**: (1) Black Sigatoka control. Increased understanding of how IPM practices influence pests and disease incidence in plantain: (2). Strategies and Instruments showing the new technologies to be used by farmers and extension agents.

**l.** **Projected impacts**: Management systems for plantain monoculture with minimum use of pesticides. Information about plantain pathosystems. A set of instruments and a new strategy to transfer information and techniques.

**m.** **Project start**: September 28, 2002

**n.** **Project completion**: October 31, 2003

**o.** **Budget**: INIAP – $ 10,000

### II.4.1 Comparative studies on the development of Black Sigatoka on Banana (Musa AAA) and Plantain (Musa sp. AAB)

**a.** **Principal investigators**, D. Vera, C. Suárez-Capello,J. Cedeño - INIAP; M. Ellis – Ohio State University. **Collaborative scientists**: R. Delgado – INIAP; Louis Maffia - Vicosa University.

**b.** **Status**: New activity, derived from II.5.

**c.** **Objectives**: **Overall:** To determine the biological basis for different management programs for Black Sigatoka disease between banana (*Musa* AAA) and plantain (***Musa*** *AAB*). **Specific: (1)** To determine variability between isolates of *Mycosphaerella fijensis* obtained from banana and plantain; (2) To determine relative susceptibility of banana and plantain to *M. fijensis*; and (3) To relate environmental factors to disease development in both crops.

**d.** **Hypothesis:** (1) Banana and plantain respond differently to *M. fijensis* attack due to their genetics, the latter being more resistant to the disease. Therefore it is necessary to use different management practices for disease control; and (2) Weather conditions (mainly rain and relative humidity) influence disease development.

**e.** **Description of research activities:** This activity will be conducted in two stages:

Laboratory and shade house. Monosporic cultures of *M. Fijensis* will be obtained both from banana and plantain and their morphological and developmental characteristics on specific media will be described. DNA will be extracted from both isolates and analyzed with appropriate molecular techniques to determine differences between the strains. Banana (var. Williams) and plantain (var. Barraganete comun) at the 8$^{th}$ leaf stage (approximately 2 months old) will be inoculated with spores from each strain. After inoculation, plants will be covered for 48 hours with plastic bags to form humid chambers. The experimental design will be a factorial $2^2$ with 6 replicates. Factor 1 is inoculum sources and Factor 2 the crop species. Three plantlets/plot will be the experimental unit. The variables to consider in this experiment will be: (a) Incubation and latent period, measured as the time between inoculation until symptom development and sporulation appearance respectively; (b) Disease severity[1], (counting the number of lesions on four 20 $cm^2$ squares on the inoculated leaf) 40 days after inoculation; (c) The infection period, counted as the time (days) that an infected leaf maintains sporulating lesions; and (d) Disease severity at the plant level will be measured on the infected leaves using Gould's 6-point scale[2].

Field trials. To test the third objective, in the Pichilingue Experimental Station two experimental plots will be planted with banana (Var. Williams) and plantain (Var. Barraganete). Two-month old plantlets will be taken to the field and planted at distances of 3 X 3 m. The experimental plot will be formed with six experimental units/crop, with three rows of plants as borders and six replicates of each plot. In the middle of the experimental field, a hygrothermograph and a pluviometer will be located to register daily weather conditions. Variables under consideration on this trial will be the Disease index[3] (dependent variable), periods of leaf wetness, quantity and duration of rain (independent). Established plots of each crop will be managed uniformly with minimal use of chemical pesticides to protect them from weeds, nematodes and insect damage. Fertilization and sucker selection will be applied according to crop needs (agronomic best management practices-BMPs).

**f.** **Justification**: Research conducted under the CRSP project during three consecutive years has made clear that management practices taken from banana are too intensive and chemically dependent for plantain. However results have shown as well that there is ample space to improve control measures, either using more intensive cultural practices or including fungicides in the IPM program for plantain. The development of IPM programs required a sound knowledge of the biology of the crop and the organisms involved. This knowledge is currently lacking for plantain.

**g.** **Relation to other CRSP activities**: This is the only project in the CRSP that deals with plantain. Results and research methods from this project will be directly applicable to other activities and projects in Ecuador.

**h.** **Progress to date:** this is a new activity, however its design takes into consideration information about Black Sigatoka on plantain derived from activities carried out with this project.

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[1] BRUN, 1963
[2] GOULD, 1994
[3] GOULD, 1994

i. **Projected outputs**: Increased knowledge of the Sigatoka-plantain pathosystem. Comparing this knowledge with that available for banana will make it possible to adjust sanitary and chemical recommendations to the actual needs of the crop.

j. **Projected impacts**: Biological parameters of the disease cycle and its relationship to main weather parameters.

k. **Project start:** September 28, 2002

l. **Project completion:** September 30, 2004 (Year 2004 will be financed by the organization that sponsor D. Vera MSc. Studies, since results of this activity will be used as MSc thesis).

m. **Budget for year 10:** INIAP, $ 6,115.

### II.4.2. Determine the efficiency of fungicide application based on a forecasting system of Black Sigatoka (*Micosphaerella fijiensis*) in plantain

a. **Principal investigators:** C. Suárez, D. Vera & J. Cedeño - INIAP-IPM CRSP; M. Ellis - Ohio State; G. Norton, J. Alwang - Virginia Tech.

b. **Status**: New activity

c. **Objectives**: (1) Determine the most effective fungicide application timing for control of Black Sigatoka in plantain; (2) Establish an appropriate methodology for the efficient use of systemic and protectant fungicides against black Sigatoka in plantain

d. **Hypothesis**: (1) Monitoring and surveillance systems are important tools for an effective IPM program; (2) Using available information, a biological forecasting system could be used as a monitoring tool for timing fungicide application on plantain; and (3) Disease impact and production costs in plantain can be reduced.

e. **Description of research activity**: Treatments will be applied to newly planted plants within the study area. Immediately after planting, the following treatments will be applied: (1) Every 14/15 days, following recommendations for commercial banana growers; (2) Fungicides applied following Foure´s disease forecasting method; and (3) Agricultural oil applied following Foure´s disease forecasting method. The following is a brief description of Foure´s method: the third and fourth leaves on treatment plants will be monitored weekly to measure the coefficient of infection (% of infection level). The decision on when to spray will depend on a comparison of the coefficient with that of the preceding week. If the latter is higher, further sprays will be applied; if it decreases, no fungicide applications will be made. Additional treatments are: (4) Cultural control through leaf surgery applied weekly during the rainy season; and (5) No treatment.

The five treatments will have 5 repetitions in a randomized complete block design. All plots will be maintained with the agronomic practices recommended for the crop, including fertilization and weevil control. Throughout the rainy season weekly leaf surgery will be part of the general management on all plots, except on number 5 (No treatment). On treatment 4, leaf surgery will be carried out weekly all year round. An azosistrobin fungicide ("Bankit") will be the main component of this program, followed in sequence by Calixin, Tilt and Clorotalonil, all accepted for Black Sigatoka disease. Disease severity will be recorded for all treatment plants, weekly. The number of leaves, as well as the yield and quality of the fruit will be evaluated. An economic analysis will also be conducted.

**f.** **Justification**: From results obtained so far, it is evident that much can be done to reduce Black Sigatoka incidence in plantain. Sanitary measures, either alone or in combination with fungicides at intervals currently recommended, are not sufficient to enable the plant to reach the flowering stage with a minimum of 10/12 functional leaves. It is important to recognize that Black Sigatoka takes 29 days for symptoms to appear in plantain (spot stage) - against 17 in banana. The subsequent latent period or streak stage (the start of sporulation) takes 28 days in banana and 34 in plantain. These are key factors to be taken into account for any fungicide program.

**g.** **Relationship to other CRSP activities**: This activity will provide valuable information to improve IPM practices under development in other CRSP activities. This study should provide a better way to establish Black Sigatoka control measures.

**h.** **Progress to date**: No work has been done so far to define the use of fungicides on plantain. This activity is based on results obtained with earlier experiments carried out during the first stage of IPM-CRSP in the area.

**i.** **Projected outputs**: Results from these studies should aid greatly in developing effective fungicide programs for use in plantain with minimum use of pesticides and good control levels of Black Sigatoka disease.

**j.** **Projected impacts:** Improved control of Black Sigatoka; reduced fungicide use on plantain; cost – benefit ratio in favor of farmers.

**k.** **Project start**: October 2002

**l.** **Project completion**: September 30, 2003

**m.** **Projected person-month of scientist time**: 6

**n.** **Budget** INIAP – $ 11,385

## II.5. Introduction of local strains of entomopathogenic fungi to control banana weevil in plantain

a. **Principal investigator(s):** K. Solís, P. Rodríguez, INIAP; R.Williams, Ohio State. **Collaborative scientists**: C. Suárez, INIAP; M. Ellis, Ohio State.

b. **Status:** Continuing activity

c. **Objectives (overall):** (1) To introduce local strains of entomopathogenic fungi from banana and striped weevils of plantain, mainly *Beauveria bassiana* & *Metarhizium anisopliae*; and (2) to determine their effect on different levels of weevil populations. **Objective for year 10**: To test under on-farm conditions the effect of applications of entomopathogens on the banana weevil (mainly *C. sordidus*) populations at different intervals.

d. **Hypothesis:** (1) Local strains of entomopathogenic fungi can be maintained in plantain as a means of reducing populations of the banana weevil (*C. sordidus)* in plantain.

e. **Description of research activity:**

Activities described for year 9 will be continued, in order to obtain strains of *M. anisopliae*. In order to accomplish this we will explore plantations with no or very little agrochemical intervention.

Several cultures (strains) of *B. bassiana* collected from experimental plots in El Carmen and Pichilingue, which have proven their aggressiveness against *C. sordidus* at the laboratory level and have shown a good competitive capability, will be applied to specific plots. Levels of parasitism/control and population densities of insects will be measured at the beginning (base line of infestation) and then at four different intervals during the period when insect activity tends to be at its highest (the rainy season). Every two weeks fungi will be recovered both from the insects and the plantation simultaneously by measuring the weevil populations. Traps and attractants used successfully in other experiments within the IPM CRSP will be compared utilizing non-parametric statistics: Friedman test and Chi square test.

f. **Justification:** Plantain yield is seriously affected by banana weevil attacks on plant corms, not only because of direct loss due to severe lodging of plants falling down and the subsequent loss of fruit weight but also indirectly because insects provide easy entrance for bacteria. Although there are no specific figures, it is estimated that half of the 60% yield loss of plantain is due to banana weevil. There is ample information (confirmed by the activities conducted in this project over the last 2 years), of successful parasitism by *B. bassiana* and *M. anisopliae* to replace insecticides. However farmers have not adopted their use because the available commercial formulations are expensive and not always effective, perhaps due to the non-uniform virulence of the strains in use. Research conducted under the IPM-CRSP project in El Carmen has shown that efforts to reduce black weevil populations have been ineffective and other strategies should be developed to tackle this. Experiments carried out during year 9, have permitted the isolation of 9 strains of *B. bassiana* but of none of *M. anisopliae*. Therefore, during year 10, experiments will continue to test control levels by increasing levels of parasitism with

*B. bassiana*, while trying to collect *M. anisopliae* from plots with various management schemes.

**g.** **Relationship to other CRSP activities**. This activity will provide information and technology to be included in the IPM strategies being developed for plantain. As well this activity is making use of information and technology (traps and attractants) found in other activities in former years.

**h.** **Project impacts**: (1) Reduction of the use of broad-spectrum insecticides and the possible reduction of production costs; (2) Reduction of health risks to farmers and local fauna; (3) Reduction of environmental contamination; and (4) If the fungi can be maintained in the soil it could reduce need for successive annual applications.

**i.** **Projected person months**: 10

**j.** **Project start**: October 2002

**k.** **Project completion**: September 2003

**l.** **Budget**: INIAP – $ 9,770

**II.7. Determine threshold levels and the effects of cultural practices over the three main nematodes affecting plantain**

**a.** **Scientists:** Randy Rivera, C. Suárez, INIAP. **Collaborative scientists**: Mike Ellis, Roger Williams, Ohio State; and C. Triviño, INIAP.

**b.** **Status**: This is a new activity but is also a follow-up from the previous year's activity conducted on the same component.

**c.** **Objectives**: (1) To determine threshold levels in plantain for the three major nematodes associated with plantain; and (2) To establish the effect of certain agricultural practices, mainly soil cover crops, use of agrochemicals and incorporation of organic amendments, on the population of nematodes in plantain.

**d.** **Hypothesis:** Agricultural practices have a direct influence on threshold levels of nematodes in plantain.

**e.** **Description of research approach:** This research will consist of two stages:

Stage 1. Under controlled conditions, plantain corms will be planted on soil with five levels of nematode infestation (700-1500-2500-5000-10000). At monthly intervals until fruit formation, samples will be processed to determine variations on the nematode population and root damage per treatment. Any alteration of the normal appearance of the aerial part of the plant (disease symptom) will be recorded and analyzed to see if it relates to nematode damage. This trial will be carried out in the Pichilingue Experimental Station.

Stage 2. An experiment will be set up at a farm with high levels of nematode infestation. Levels of nematode populations present at the onset of the experiment will be measured. Then, four treatments will be compared under a complete randomized design with 4 replicates and 20 production units per plot. Treatments under consideration are residue management and soil cover, chemical usage (mainly fertilizers and herbicides) and soil improvement with organic matter.

**f.** **Justification**: Plantain yield in Ecuador is generally low; national averages are 8 metric tons per hectare annual when potential yields are 15 metric tons. Apart from the foliar pathogen causing Sigatoka disease, corm and root damage due to nematode attack contribute to low yields. However, work conducted over the last two years in the CRSP project has shown that (a) *R. similis* and relatively large populations of *Meloidogine spp*. and *Helicotilencus* are found unevenly distributed around the area; (b) IPM practices negatively affect the population of root damaging nematodes and increase the beneficial species, particularly *Dorilaimus* and *Rabditis*; and (3) The use of agrochemicals in general, seems to affect the type and quantity of nematodes present . No similar studies have ever been conducted in plantain, at least in Ecuador.

**g.** **Relationship to other CRSP activities:** This activity will provide key information for determining one of the IPM components (nematode attack) required for IPM in plantain, being developed in another CRSP activity within the same area.

**h.** **Progress to date**: New activity. Procedures set up and personnel trained previously in nematode analysis will be used for this year's work.

**i.** **Projected outputs**: (1) Clear information about root diseases caused by nematodes in plantain, (2) An established relationship between nematode incidence and technology level.

**j.** **Projected impacts**: This activity should provide valuable information about root diseases in plantain in Ecuador. The expected result will allow planning control decisions as part of the integrated management of the crop. It will serve as baseline for future work on control measures.

**k.** **Project Start**: October 2002

**l.** **Project Completion**: September 2003

**m.** **Person months**: 12

**n.** **Budget:** INIAP – $ 4,710

## II.8. IPM for Plantain/Coffee Agro forestry Systems in Northwestern Ecuador: A Land use alternative to low quality pasture within a fragile agro ecosystem

a) **Principal investigator**: C. Suárez-Capello, C. Belezaca- INIAP; F. Echeverría- MAQUIPUCUNA;W. Flowers - Florida A&M University, R. Carroll - University of Georgia; R. Williams, M. Ellis - Ohio State University.

b) **Collaborating Scientists**: Rebecca Justicia, Fundación Maquipucuna; R. Rivera, C. Triviño - INIAP.

c) **Status**: Continuing activity.

d) **Objectives**: **General**: Development of an IPM program for crop management in the fragile subtropical ecosystem of the Andean slopes. **Year 10**: (i). To determine incidence, seasonality and relative abundances of pests and diseases within six different crop systems on the northwestern Andean slopes. (ii). To develop basic information about environmental impacts of Agroforestry systems. (iii). To study the life cycle and ecological requirements of Amauta cacica (Castniidae, Lepidoptera), a newly identified pest of plantain in Northwestern Ecuador. (iv). To investigate the effects of sugarcane residue as a soil amendment to modify nematode guild structure. (v.) To investigate the effects of simulated drought on pest and beneficial nematodes.

e) **Hypotheses:** 1) Polyculture cropping will show a lower incidence of pests and diseases than monoculture plantations. 2) Determination of major pest and disease constrains in Andean subtropical cropping systems will facilitate development of IPM management strategies for farmers in fragile ecosystems subject to increasing colonization pressure. 3) Bagasse byproducts from sugarcane, readily available in the area from sugarcane processing, will provide an excellent substrate to facilitate improved biological control of pests and diseases while at the same time providing protection of soil structure and limiting erosion. 4) Simulated drought will increase spatial variation in soil-dwelling pests and increase pest nematodes relative to free-living beneficial nematodes.

f) **Description of research activity**: This project is being carried out on Finca San Rafael de Orongo (hereafter referred to as Orongo), located on theNorthern border of Reserva Maquipucuna, 80 km. NW of Quito. The polyculture cropping system design consists of four blocks, each with 6 treatments: (1) Single rows plantain + coffee; (2) Double rows of plantain + coffee; (3) plantain + citrus; (4) plantain alone; (5) coffee; (6) citrus. Each block has 1114 m2 with treatments plots of 120 m2. The established plots of each cropping system are being managed uniformly, with chemical pesticides used only to control major outbreaks. Soil and root sampling and corresponding processing are being conducted to determine nematode diversity and population levels within each system. Basic meteorological equipment has been placed near the cropping systems at Orongo to monitor main weather conditions (rain, relative humidity and temperature) throughout the year. Simultaneous data are being collected from a nearby meteorological station for future comparison and analysis. These weather conditions will then be related to pest and diseases present at the same time. Two Malaise traps have been located in the agroforestry plots and are activated four times a year to get periodic snapshots of the general insect  fauna of the project area, and to specifically collect parasitic Hymenoptera and alate ants, as well as parasitic Diptera (Tachinidae).  The malaise traps are supplemented with yellow pan traps, which are effective at collecting Diptera, micro-Hymenoptera, and Homoptera.  Traps are placed to capture possible variations in the insect communities in the different combinations of crops.  The plots are monitored at quarterly intervals and the insects are separated and sorted to order and major family at the Pichilingue laboratory. Tissue samples from diseased plants are collected and processed on various media in the Pichilingue laboratories to determine the presence of plant pathogens and vascular wilts. Every six months soil and root samples from each plot are taken and processed at Pichilingue laboratories for nematodes. The survey of prevalent weeds in every cropping system will be completed during dry season of year nine

Last year was a record drought for the northwestern Andean slope and we believe that this was the major reason why spatial variation in nematode abundance and diversity increased and why root-parasitic nematodes increased relative to free-living beneficial nematodes. In order to examine this possibility we plan to create simple rain shields around  twenty 6 month old plantain plants. Half will receive sugarcane bagasse every 2 months as a soil cover. Plants with rain shields will be irrigated to prevent permanent wilting. Twenty plants will receive ambient rainfall and, if necessary, augmented on a monthly basis to equal the 10 year monthly average. Ten plants will receive bagasse soil cover. Soil and root samples will be taken monthly and examined for nematodes and for root damaged caused by nematodes.

The identity of the Castniidae species damaging plantain in Orongo is Amauta cacica, not Castniomera humbolti as had been generally assumed. While C. humbolti is well known for damaging plantain elsewhere in Central and South America, this is the first time A. cacica has been demonstrated to be an economic species.  Nothing has been recorded of its life cycle or biology.  Collections of larval and pupae material of the insect have been completed, and observations of the tunneling behavior of mature larvae in plantain pseudostems are underway. In the coming year, studies of adult feeding and egg laying behavior will be carried out, and the possibility that a native Heliconia species might  be an  original host will be tested. Simple experiments will be set out to comprobar apparent relationship between bagasse - nematofauna and bagasse - draught.

**g) Justification**: This highly vulnerable Andean region requires production systems that simultaneously offer an economic activity to farmers and minimizes damage to the environment. Sugarcane is a major land use activity in the region, but bagasse and ash byproducts now constitute a source of contamination and few attempts have been made to find alternative uses for them. On the other hand, farmers do not have many other alternatives for productive activities in the area. What farmers now have available is a mixture of coffee, banana, citrus and low  quality pasture. Coffee, banana and citrus are scattered in farms and these crops presently suffer high mortality from pests and diseases. The potential for this agro-forestry system is good, provided farmers can solve their ecological (mainly soil erosion) and phytosanitary constraints.

The survey of weeds, pests and natural enemies will be a baseline to direct subsequent specific studies of the use of individual species in biological control.  The survey will focus on the Diptera family Tachinidae and the families of micro-Hymenoptera because these groups are where agriculturally significant natural enemies are most likely to be found.  Subsequent monitoring of pests and their enemies will provide a measure of the environmental impact of different cropping systems, and help establish priorities of which pest problems are the most important. Additionally, the survey will give managers of conservation areas information about insect interactions between protected forest and neighboring agroforestry areas. Ants are a significant component of all tropical ecosystems and can have significant impacts in tropical crop systems, such as being important predators of pests or, on the other hand, exacerbating problems with pest aphids and scales. More relevant to the problems of Western Ecuador, ants have been used in Cuba as a natural control of the black banana weevil. We will determine if the species used in Cuba (Pheidole megacephala, Solenopsis geminata, and Wasmannia spp) are present, or if related species can fulfill the same function.

The La Niña cycle of the Southern Climate Oscillation generally brings a drier wet season to northwestern Ecuador. Last year this cycle caused a record drought and major crop losses. There is some concern that global climate change will deepen the La Niña cycles and create more frequent and more severe droughts. Whether this patterns unfolds or not, it is still important to understand how climate variability influences IPM outcomes. Our simple rain shield experiments will provide the first insight into the relationship between droughts and nematode guild structure and density and root damage.

**h) Relationship to other CRSP activities**. Any information on the type and relative abundance of pests and diseases of this agroforestry system would be of direct benefit to other CRSP activities, both in Ecuador and in other subtropical regions. This research is related to the plantain activity being carried out in this project, especially that concerned with Black Sigatoka disease, nematodes and the black Banana weevil. The work is also directly relevant to CRSP plantain work at Pichelingue.

**i) Progress to date**: At the Orongo farm, plants in the new research plot are entering the yield stage. A weed inventory has been completed. Adults of the Castniidae species attacking plantain have been reared and a positive identification of the species has been obtained. As noted above, the presence of this species as a pest was not expected from any previous work on plantain pests. Initial results of the insect pest and natural enemies inventory are being tabulated, as are results of the disease survey.

In year two (2000/2001), the addition of bagasse to plantain resulted in a significant increase in the diversity and abundance of beneficial nematodes and a decrease in pest nematodes. Year three (2001/2002) was a record drought year. Spatial variation in nematode diversity and abundance increased. The abundance of free-living nematodes decreased.

**j) Projected outputs**: (a) A better understanding of the incidence of root-damaging pests and foliar diseases in polyculture agroforestry; (b) First-hand information about the incidence, seasonality and severity of phytosanitary constraints for three important crops within an agroforestry system design suitable for sustainable agriculture in the subtropical Andes; (c) An inventory of local faunas of parasitic Hymenoptera, Diptera and ants in areas of agroforestry and in adjacent forests; (d) Knowledge of the occurrence and behavior Amauta cacica and its potential for spreading to other plantain growing areas; (e) a better understanding of how climate variability (droughts) influence IPM offorts.

**k) Projected impacts**. (1) An inventory of insect pests, weeds, diseases and beneficial fauna of the Andean North Occidental slope, which will help farmers and extension personnel more rapidly identify and respond to pest and disease problems; (2) a ranking by importance of pests and diseases affecting plantain, coffee, and citrus in this agroforestry system, as well as data on the proportion of beneficial, predatory and parasitic insects are present in and around the cultivated areas; (3) life history and other biological data on Amauta cacica, which will be essential for designing counter measures against this lepidopteron, and which could also be useful to those working with other damaging species in the Castniidae.

**l) Project start**: October, 2000.

**m) Project completion:** September,2004.

**n) Projected person-months of scientist time per year**: 6 months.

**o) Budget:** INIAP – $ 9,240; FAMU – $ 5,040

## III. Socioeconomics

### III.1. Modeling Impacts of Changes in Pest Management Technologies

**a.** **Scientists:** V. Barrera, J. Ochoa, C. Suarez, G. Suquillo – INIAP; J. Alwang and G. Norton – Virginia Tech

**b.** **Status:** Continuing activity

**c.** **Objectives: (Overall)** (1) To assess the impacts of IPM technologies on land use and management, farmer income, and pesticide use, (2) To assess the economic impacts of the IPM technologies developed on the IPM CRSP, including the distribution of impacts to different producer and consumer groups such as the poor **(Current year)** Continue impact assessment for the plantain IPM on the coast; initiate impact assessment for andean fruits.

**d.** **Hypotheses:** (1) Land use and management, farmer income, and pesticide use will not be affected by IPM technologies generated on the IPM CRSP; (2) IPM CRSP technologies do not have economic impacts or spillovers; and (3) Different socioeconomic groups are not impacted by these technologies.

**e.** **Description of research activity:** To address objective two, it is proposed that the per unit cost reductions measured or projected due to IPM CRSP technologies be combined with measured or projected information on adoption and included in an economic surplus model to generate aggregate benefits. All changes in input use, outputs, and prices are being measured for each of the CRSP experiments. This information can be used to help generate per unit cost changes. The data from the plantain experiments on the Coast will be analyzed. Baseline data will be collected to describe the socioeconomic conditions of growers of naranjilla; impacts will be estimated using the baseline together with cost data from the field experiments. Additional work will be undertaken to examine the distributional effects by farm size, region, etc.

**f.** **Justification:** Knowledge of farm, regional, and aggregate level impacts of IPM is essential for designing IPM programs and pest management recommendations, for justifying programs and research activities, and for designing environmental policies and programs. These impacts often spill over across regions and have differential effects on socioeconomic groups. Disaggregating the impacts by socioeconomic group will provide a template for subsequent joint research activities in other sites as well. It also provides the first attempt to estimate profitability of plantain and naranjilla IPM.

**g.** **Relation to other research activities at the site:** This project directly complements other research activities underway in the plantain and narajilla growing regions. It builds upon the technical data being generated on an ongoing basis by CRSP researchers.

**h.** **Progress to date:** During 1999, this activity was integrated into the overall work plan of the Tradeoffs Project of the Soil Management CRSP. During Year 7 of the IPM-CRSP work in this project consisted of field data collection and initiation of two student theses. During 2000-2001 baseline field collection of farm production data was completed by David Quishpe, a student of the U. Central, in collaboration with Ing. Luis Escudero, the research assistant originally hired by the project. Ing. Escudero is now hired by the sister Validation project and is running a selection of the Farmer Field Schools in Carchi. Egr. Quishpe collected detailed parcel level production data and knowledge, attitudes and practices of participating farmers towards pesticides and their use. This data was registered in computer data bases for econometric analysis and use in the Tradeoffs Model as well as for establishing a baseline for impact analysis for changes in productivity due to adoption of IPM. The thesis of Quishpe and the tradeoffs analysis was completed and was written up in year 9. New analysis of plantain IPM impacts began in year 9 and will be completed in year 10. Naranjilla impact assessment will begin in the current year.

**i.** **Projected outputs:** The activity will produce both models and reports that describe impacts of the IPM research on plantain and naranjilla in Ecuador.

**j.** **Projected impacts:** The results should generate information on which technologies to promote in training programs, on which IPM alternatives might justify further research, and on the benefits of pest management policies or regulations that influence pesticide use. It should provide information to help in justifying IPM programs.

**k.** **Start:** September 1998

**l.** **Projected completion:** September 2003

**m.** **Projected person months of scientist time:** 24

n. **Budget**: INIAP – $ 1,980; Virginia Tech – $ 35,465

## III.2. Gender analysis of effectiveness of different methodologies of diffusion for the transferal of IPM practices for different agro systems in Ecuador

a. **Principal investigators:** Colette Harris (Virginia Tech.); José Cedeño (replaces Danilo Vera who is on study leave), **Collaborating scientists**: Carmen Suárez - INIAP; George Norton, Jeff Alwang - Virginia Tech.

b. **Status**: Continuing activity but a follow-up to year 9 gender activity on the coast.

c. **Objectives**: (1) To develop basic information about family participation in plantain farming; (2) To train research scientists related to the IPM-CRSP and extension agents in the coastal area of Ecuador in gender-sensitive community-participative methodology, so as to improve their ability to communicate with farmers.

d. **Objective for year 10**: (1) To carry out a qualitative survey with six to ten plantain farming families looking at family decision-making, attitudes towards the use of chemicals and other related issues. (2) To continue with the training of scientists.

e. **Hypothesis**: (1) More in-depth knowledge of family attitudes and practices will help in designing appropriate approaches to technology transfer; (2) Gender-sensitive scientists and extension workers will be better equipped to for transferring IPM technologies to farming communities

f. **Description of research activity**: (1) In the coastal region a small group of 6-10 farm families, half from a younger and half an older age-group, will be selected for an in-depth study of the decision-making mechanisms within the family and their attitudes towards chemical usage and crop management. Each family will be visited regularly during 2-3 months. (2) INIAP scientists and a carefully selected group of 8-10 extension workers will be trained in gender-sensitive community-participatory methodologies. There will be two types of training. One will be a series of workshops to be carried out by Colette Harris. The other will be ongoing informal work within INIAP and by the group of INIAP scientists for the extension workers. Prior to the start of their training all these persons will complete a questionnaire on their current attitudes and a similar questionnaire will be applied at the end of the training period to test attitudinal change.

g. **Justification:** (1) Gender analysis should provide information about new approaches to research and new constraints that so far are being overlooked; (2) IPM technology is not simple to transfer. In order to do so it is necessary to have an integrated understanding of the crop and its problems. Therefore, it is important to have transfer agents equipped to communicate complex types of information.

h. **Relationship to other CRSP activities**: (1) This continues from the base-line quantitative survey carried out with plantain farmers in year 9 and its results will be used to design appropriate technology-transfer methodology. (2) The training activity cuts across all the activities carried out on plantain by preparing the personnel to work at all levels with the farming community.

i. **Progress to date**: A quantitative base-line survey was conducted on some 300 farms in year 9 to obtain data on approaches to crop management. The results of this survey will be taken into account in planning the year 10$^{th}$ activity. The activity will also be based on the reactions of farmers to workshops carried out in El Carmen during year 9 as well as the socio-economic activity in the village of San Pedro in Carchi of year 9.

j. **Projected outputs**: (1) Better understanding of internal family dynamics in relation to decision-making, chemical usage and crop management. (2) Scientists and extension workers capable of gender-sensitive communication with farming families (3) Written reports and scientific papers.

k. **Projected impacts:** (1) Greater awareness of farm family attitudes and dynamics; (2) Improved communication between scientists, extension agents, and farming families.

l. **Project start**: October 1, 2001

m. **Project completion**: September 29$^{th}$, 2003

n. **Projected person-month of scientist time**: 12 months

o. **Budget:** INIAP – $ 7,150; Virginia Tech - $ 5,060

## III.3. Validation and Diffusion of Models for Integrated Pest Management (IPM) of Potato in the Carchi and Bolívar, Ecuador

a. **Principal investigators:** V. H. Barrera, L. Escudero, J. Suquillo, C. Monar, A. Rea, M. Pumisacho - INIAP, S. Sherwood - CIP-Quito; G. Norton and J. Alwang - Virginia Tech. **Collaborative scientists:** J. Revelo, P. Gallegos – INIAP; C. Harris - Virginia Tech.

b. **Status:** continuing activity

c. **Objectives**: (1) To validate and disseminate models of integrated pest management on potato, in the communities of the Provinces of Carchi and Bolivar; (2) To train potato producers in Carchi and Bolivar, on IPM components; (3) To evaluate the impact of validation and training on models of integrated pest management.

d. **Hypothesis**: Potato IPM models fit the production systems of the communities of the provinces of Carchi and Bolivar, and are contributing to the improvement of the productivity and sustainability.

**e.** **Description of activities**: INIAP, through "Units of Validation and Technology Transfer" of Carchi and Bolivar, and with the support of the "Nucleus of Technical Support and Training", as well as the Plant Protection Department, of Santa Catalina Experimental Station of INIAP and the International Potato Center, during the last three years have consolidated their experience on Validation and Diffusion of Technologies on Integrated Pest Management, on the chief Plagues and Diseases of Potato (IPM); over this experience, where it is being utilized the approach of the Field Schools (FS), it is expected to transfer the knowledge to farmers, by means of the participatory training and the validation and diffusion of the IPM models. The activities set forward on this study are: location, diagnosis, organization, implementation, following and evaluation of the Field Schools.

**f.** **Justification**: Some studies performed in Ecuador (Barrera *et. al*., 1999; Barrera *et. al*., 2000) show that the main phytopathological problems of potato crop in Ecuador are: potato late blight (*Phytophthora infestans*), the andean weevil (*Premnotrypex vorax*), the central american tuber moth (*Tecia solanivora*) and the borer fly (*Liriomyza huidobrensis*). These pests are present every year in the agroecosystem of potato production areas of Ecuador. Their control is based on the excessive use of pesticides. In view of this situation, during the last two years, the project sought to develop and implement practical IPM activities. These activities are aimed to minimize use of pesticides and minimize risks to farmers health. IPM components will be adjusted to specific areas of Carchi and Bolívar provinces, where work has been done. This work must be validated and diffused in other potato growing areas, since these provinces contribute 56% of total national potato production.

**g.** **Relationship to other CRSP activities at the site**: This activity is related to all other IPM-CRSP activities being performed in Carchi and Bolivar, as well as with activities from other projects.

**h.** **Progress to date**: Communities were selected in the counties Tulcán, Montúfar and Espejo of Carchi province, and at Guaranda county in Bolívar province. These are representative areas where the andean weevil and late blight are the main limiting factors for potato production. An IPM training curricula was elaborated according to the different development stages of the crop. This was performed gradually, through three hour sessions, once a week. 230 training sessions were performed and 193 potato farmers got trained and graduated. Currently, 101 farmers are being trained. Three field days were held with 675 participants. Interchange field trips among farmers of the region and of the Field Schools were conducted, in order to share experiences.

Regarding to the implementation of the IPM components, 28 plots were evaluated, 14 of which contained IPM components and the other 14 with conventional farmer practices. Results reveal that IPM for the Andean weevil, potato moth, late blight and leaf miner has helped reduce production costs and lower use of highly dangerous pesticides. Preliminary data analyses reveals that in Carchi, the number of phytosanitary controls per hectare has diminished from 9 to 4; in Bolivar the average number of controls per hectare have declined from 6 down to 3. Utilizing the IPM techniques the farmers can reduce the number of controls up to an average of 50%. In relation to costs in Carchi 9 controls with the conventional system resulted in average expenses of $430 per ha, while 4 controls with IPM lowered average expenditure to $258 per ha. In Bolivar, farmers making 6 pesticide applications spent an average of $288 per ha, whilst using 3 applications, they spent an average of $194 per ha. This means that using the IPM techniques, the farmers can reduce pesticides expenditure up to an average of 40%.

The Field Schools have attracted the interest of a number of other institutions, national as well as international ones. The Food and Agriculture Organization (FAO) of the United Nations Organization and the Association of the Industry of Crop Protection and Animal Health (APCSA) are supporting the implementation of FS´s in Carchi and Bolivar.

**i.** **Projected Outputs**: (1) Models of Integrated Pest and Disease Management mated to the agro-social-economic conditions of the potato farmers in Carchi and Bolívar; (2) A strategy for training and diffusion of IPM models; (3) Study the impact of the validation and training of the models of Integrated Pest Management.

**j.** **Projected impacts**: (1) Reduction in pesticide imports; (2) Reduction of health risks for potato producers and consumers; (3) Higher environmental protection due to the reduction of pesticides use.

**k.** **Project Start**: October 2000

**l.** **Project Completion**: September 2003

**m.** **Project Person-Months of Scientists Time per Year**: Chief investigator, 8 months; agricultural investigators, 8 months; field technicians, 12 months.

**n.** **Budget:** INIAP – $ 16,170

INTEGRATED PEST MANAGEMENT -- COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), INIAP SITE IN ECUADOR

| ACTIVITY | | SCIENTISTS | BUDGET ($) |
|---|---|---|---|
| **MULTIDISCIPLINARY ON-FARM PEST MANAGEMENT EXPERIMENTS** | | | |
| II.2 | Development of biological control methods for two major potato pests in Ecuador. The Andean Potato Weevil Premnotrypes vorax and the Central America Tuber Moth Tecia solanivora. | Jovanny Suquillo, Patricio Gallegos -INIAP; Azis Lagnaoui-CIP | INIAP/CIP $20,988<br>Ohio State $20,336 |
| **DEVELOPING IPM PROGRAMS FOR ANDEAN FRUITS IN ECUADOR** | | | |
| II.3.3 | Developing IPM programs for naranjilla (*Solanum quitoence*) in Ecudor | J. Ochoa, P. Gallegos, M. Insuasti -INIAP; M. Ellis, R. Williams - Ohio State University | INIAP $13,970<br>Ohio State $ 3,780 |
| II.3.6 | Developing IPM programs for tree tomato (*Solanum betaceum*) in Ecuador | J. Ochoa, P. Gallegos, M. Insuasti -INIAP; M. Ellis, R. Williams - Ohio State University | INIAP $ 9,020<br>Ohio State $ 3,780 |
| II.4 | Development of IPM Programs for Plantain Systems in Ecuador | C. Suarez-Capello, J. Cedeno, I. Carranza - INIAP; R. Williams, M. Ellis - Ohio State University; J. Alwang, G. Norton, C. Harris - Virginia Tech | INIAP $10,000 |
| II.4.1 | Comparative studies on the development of Black Sigatoka on Banana (Musa AAA) and Plantain (Musa sp. AAB) | D. Vera, C. Suarez-Capello, J. Cedeno - INIAP; M. Ellis - Ohio State University | INIAP $ 6, 115 |
| II.4.2 | Determine the efficiency of fungicide appliation based on a forecasting system of Black Sigatoka (*Micosphaerella fijiensis*) in plantain | C. Suarez-Capello, D. Vera, J. Cedeno - INIAP; M. Ellis - Ohio State University; G. Norton, J. Alwang - Virginia Tech | INIAP $11,385 |
| II.5 | Introduction of local strains of entomopathogenic fungi to control banana weevil in plantain | K. Solis, P. Rodriguez - INIAP; R. Williams - Ohio State Unviersity | INIAP $ 9,770 |

| | | | |
|---|---|---|---|
| II.7 | Determine threshold levels and the effects of cultural practices over the three main nematodes affecting plantain | Randy Rivera, C. Suarez - INIAP | INIAP $ 4,710 |
| II.8 | IPM for Plantain/Coffee Agro forestry Systems in Northwestern Ecuador: A Land use alternative to low quality pasture within a fragile agro ecosystem | C. Suarez-Capello, C. Belezaca - INIAP; F. Echeverria - MAQUIPUCUNA; W. Flowers - Florida A&M University, R. Carroll - University of Georgia; R. Williams, M. Ellis - Ohio State University | INIAP $ 9,240<br>FAMU $ 5,040 |
| **SOCIOECONOMICS** | | | |
| III.1 | Modeling Impacts of Changes in Pest Management Technologies | V. Barrera, J. Ochoa, C. Suarez, G. Suquillo - INIAP; J. Alwang, G. Norton - Virginia Tech | INIAP $ 1,980<br>Virginia Tech<br>$35,465 |
| III.2 | Gender analysis of effectiveness of different methodologies of diffusion for the transferal of IPM practices for different agro systems in Ecuador | C. Harris - Virginia Tech; Jose Cedeno | INIAP $ 7,150<br>Virginia Tech $ 5,060 |
| III.3 | Validation and Diffusion of Models for IPM of Potato in the Carchi and Bolivar, Ecuador | V. H. Barrera, L. Escudero, J. Suquillo, C. Monar, A. Rea, M. Pumisacho - INIAP; S. Sherwood - CIP-Quito; G. Norton, J. Alwang - Virginia Tech | INIAP $16,170 |

# Tenth Year Work Plan for the Albanian Site

IPM CRSP research activities in Albania will be initiated in year ten with three major types of activities: (a) educational/planning activities and crop/pest monitoring, (b) multidisciplinary pest management experiments, and (c) socioeconomic analyses.

## I. Baseline Survey and Crop/Pest Monitoring

**I.1. Title:** Meeting the educational and planning needs for Olive Integrated Pest Management

a. **Scientists:** Charlie Pitts, Greg Luther, Keith M. Moore, Doug Pfeiffer, Beth Teviotdale, Louise Ferguson, Milt McGiffen, Fadil Thomaj, Myzejen Hasani, Rexhep Uka, Magdalena Bregasi, Shpend Shahini, Bujar Huqi, Vangjel Jovani, Brunilda Stamo, Harallamb Pace, Josef Tedeschini, Hajri Ismaili, Mendim Baci, Zaim Veshi, Dhimiter Panajoti, Bardhosh Ferraj

b. **Status:** Finishing third year; project completion

c. **Objectives:** To (1) provide opportunity to meet to plan forthcoming CRSP activities, (2) provide educational opportunities for Albanian and American cooperators in biological aspects of olive pest management system, and (3) allow dissemination of CRSP results to growers.

d. **Hypotheses:** Progress on developing a non-disruptive IPM system for Albanian olives will be speeded if educational opportunities are pursued, and Albanian and American collaborators can meet to discuss problems and limiting factors to potential alternatives, and credibility of our project among growers will be enhanced with early visibility of our efforts and results.

e. **Description of research activity:** Participate in grower training sessions being organized by private and state-organized extension efforts, as appropriate. Planning will begin on a future proposal for participatory IPM in Albania.

f **Justification:** The need for close collaboration among Albanian and American counterparts continues, to facilitate planning of research. Now that the current olive IPM project is finishing, the time is opportune to begin planning efforts to implement participatory IPM in Albania. Implementation of CRSP results will be facilitated by grower workshops, attempting to reach both male and female farmers.

g. **Relationship to other research activities at the site:** The planning and educational activities proposed will support all other Albanian objectives.

h. **Progress to date:** Three years of olive research funding are nearing an end.

i. **Projected outputs:** Detailed research plans will be produced. Grower training will gain a foothold.

j. **Project impacts:** Understanding by American participants of Albanian olives and the research situation will be enhanced. Expertise in biological control of both Albanian and American participants will be increased. The Albanian researchers will be better able to analyze research data and present in a format suitable for publication. The likelihood of success of the other Albanian objectives will be greatly increased, including adoption of new practices by growers.

k. **Project start:** September 1999

l. **Projected completion:** September 2002

m. **Projected person-months of scientist time per year:** 6 months

n. **Budget:** $6881 -- Albanian institutions; $0 -- Penn State; $0 -- University of California; $2540 -- Virginia Tech.

**I.2** **Title**: Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems.

a. **Scientists:** F. Thomaj, M. Bregasi, J. Tedeschini, H. Pace, R. Uka, M. Hasani, B. Stamo, V. Jovani – Albanian institutions; C. Pitts – Penn State; L. Ferguson, B. Teviotdale, M. McGiffen – University of California; D. Pfeiffer – Virginia Tech

b. **Status:** Finishing third year; project completion

c. **Objectives:** To (1) Determine incidence and abundance of pests and natural enemies; (2) Estimate economic injury levels; (3) Determine parasitism rates of major insect pests; (4) Determine the major weed species dominant in olives.

d. **Hypotheses:** (1) Pest and natural enemy population fluctuations affect crop production in greenhouse production systems (2) Weed species and growth pattern are affected by the vegetable cropping system.

e. **Description of research activity:** Monitoring is being carried out in the research site at Vlora. Monitoring of insect pests, diseases and nematodes is carried out intensively at the key site. Insect pests and natural enemy populations are monitored by direct counts/sweet-net sampling /vacuuming /pitfall traps/ water pan traps/ pheromone traps, etc. Sample trees are randomly chosen. Pest and crop damage are monitored on these trees. For leaf-feeding insects, three tips or leaflets are selected. All insects on these samples and the total number of leaves are counted. For fruit feeding insects, representative fruit are selected from each sample tree and all pest insects are counted. Each of the selected trees is rated for disease incidence and other damage concurrent with insect evaluations. For passive sampling techniques (Pan Traps, Pit Fall Traps, etc.), 6 devices have been placed in each field. Traps are emptied and preservative replaced after each evaluation.

Parasitism rates are determined by collection of eggs, larvae and pupae and reared in the laboratory. Crop damages are estimated by direct counts or by using a scoring scale. Abundance of diseases is monitored using appropriate scoring scales. Incidence and abundance of nematodes, root diseases and insect damages are monitored by sampling under the tree. Randomly selected trees are sampled for evaluation during each sampling period.

Several representatives of each pest and beneficial will be preserved in a reference collection. The weed species composition and density will be determined.

**f.** **Justification:** It is important to understand the seasonal fluctuations of pests and natural enemies and their association as it will lead to the identification of research issues and priorities for solving pest problems in olive production systems. Weeds reduce yield of olives and contribute to increased production cost. In the development of a weed management strategy, the first step is to know the weeds and their infestation levels and seasonal patterns in a particular crop. Sampling must be extended into November 2002, the normal harvest period for olives in Albania.

**g.** **Relationship to other research activities at the site:** The study will help in prioritizing research in other IPM CRSP activities.

**h.** **Progress to date:** Nearing an end in olive. Work on this project was initiated in spring, 2000. Orchard blocks have been cultivated and pruned at Shamogjin, a research grove near Vlora operated by Fruit Tree Research Institute. Pheromones were used for the monitoring of key pests for the first time in Albania. The population dynamics of olive moth, *Prays oleae*, olive fruit fly, *Bactrocera oleae*, and black scale, *Saissetia oleae,* were clarified and more information made available to better control the main pests of olive crop. A new pest of olive flowers was identified. Field monitoring revealed the presence of leaf spot and olive knot as two more important diseases of olive trees in Vlora district. Monthly observations show that the higher level of leaf spot disease appeared during March-April and the new galls of olive knot became visible during May-June. Several species of nematodes were collected infesting olive orchards and olive nurseries. Nematode determination is underway. To develop an effective weed control strategy, measurements of weed density and identification of dominant species has been conducted in experimental fields. After data collection the dominant species among the shrubs were *Dittrichia viscose* (L.) W. Greuter and *Rubus ulmifolius* Shott, among the grasses *Agropyrum* spp. L., *Bromus* spp. etc, and among broad leaves weeds *Soncus asper* L., *Trifolium* spp., *Cirsium arvense* etc. The number of weeds estimated in monitored area varies from 250-300/m$^2$.

**i.** **Projected outputs:** (1) Improved knowledge of key pests, population fluctuation patterns and associations between pests and their natural enemies; (2) identified pests and natural enemies, and reference collection initiated; (3) improved understanding of the role of natural enemies in pest management.

**j.** **Projected impacts:** (1) Identification of appropriate research activities; (2) An effective weed control strategy will be developed from data generated from the study.

**k.** **Project start:** October 1999

**l.** **Projected completion:** September 2002

**m.** **Projected person-months of scientist time per year:** 20 person months

**n.** **Budget:** $10117 -- Albanian institutions; $0 -- Penn State; $0 -- University of California; $0 -- Virginia Tech

## II. Multidisciplinary Pest Management Experiments

**II.1** **Title:** Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality

**a.** **Scientists:** D. Pfeiffer – Virginia Tech; F. Thomaj, M. Bregasi, J. Tedeschini, D. Panajoti, B. Ferraj – Albanian institutions; L. Ferguson – University of California; C. Pitts – Penn State.

**b.** **Status:** Finishing third year; project completion

**c.** **Objectives:** (1) To determine the optimal time to harvest olives to minimize olive fly infestation and maximize oil yield and quality; (2) To determine the effect of storage time on olive fly infestation and percent olive oil quality; (3) To determine the effect of harvest date on return bloom and yield the subsequent year.

**d.** **Hypothesis:** After temperatures drop below 34C olive fly infestation, which decreases oil quality (by increasing % acidity), increases. At the same time olives are maturing and accumulating oil content (% oil/kg of fruit), or yield. As these two processes proceed there is an arc of time when oil yields (% oil/kg of fruit) and quality (% acidity) are least affected by olive fly infestations and therefore give maximum return to the grower. There is an optimal harvest time if these two processes can be balanced. Harvest can be timed to maximize increasing yield and minimize increasing olive fly infestation.

**e.** **Description of research activity.** A 500-tree block has been selected at Vlora experimental orchards. This will be divided into 5, (I-V) blocks. Within each block 35 uniform trees are selected and using a random number table 5 sub-samples are assigned to each of the 7 harvest date treatments (1/11, 15/11, 1/12, 15/12, 1/1, 15/1, 1/2).

**f.** **Justification:** If growers can select the optimal time to simultaneous maximize yield and minimize olive fly infestation possibly chemical control for olive fly can be minimized. Funds are included to pay for chemical oil analysis in U.S. or Greece. Sampling must be extended into November 2002, the normal harvest period for olives in Albania.

g. **Relationship to other research activities at the site:** Effectiveness will be enhanced by lowered crop-bearing canopy developed in the pruning experiment. Prevention of pesticide applications for olive fruit fly will favor biological control of black scale, and organic management of olive moth.

h. **Progress to date**: Work on this project was initiated in spring, 2000. Orchard blocks have been cultivated and pruned at Shamogjin, a research grove near Vlora operated by Fruit Tree Research Institute. Positive results have been obtained to date, with olive content reaching nearly maximum levels before the third generation of olive fruit fly. Greater resolution is needed in assessing individual oil quality components in addition to total acidity.

i. **Projected outputs:** Improved IPM management of olives.

j. **Projected impacts:** Increased net returns and decreased use of pesticides.

k. **Projected start:** September 1999

l. **Projected completion:** September 2002

m. **Projected person-months of scientists time per year:** 12

n. **Budget:** $33367 -- Albanian institutions; $ 0 -- Penn State; $ 0 -- University of California; $0 -- Virginia Tech.

II.2 **Title:** Organic Pest and Vegetation Management

a. **Scientists:** J. Tedeschini, B. Stamo, H. Pace, B. Huqi, Sh. Shahini, Dh. Panajoti, H. Ismaili, M. Bacaj – Albanian institutions; M. McGiffen and L. Ferguson - Univ. of California

b. **Status:** Finishing third year; project completion

c. **Objectives:** Determine the effect of vegetation management on pest populations and yield.

d. **Hypotheses:** (1) Vegetation management affects pest populations and yields of olive. (2) Organic vegetable production can be profitable for Albanian farmers.

e. **Description of research activity**: A randomized complete block experiment has been set up in two fields, an organic production system, and one using synthetic pesticides and fertilizers. Each treatment is replicated five times. The seven conventional treatments include: 1) Cover crop – mixed legume and rye for winter growth, 2) untreated control, 3) non-selective herbicide - glyphosate, 4) selective herbicide - diuron, 5) grazing, 6) plowing, 7) straw mulch. Synthetic insecticides and fungicides are used for the conventional production field. The organic field has five of the above treatments, and does not include the two herbicide treatments. Copper sulfate and Bordeaux Mix are used for pathogen control in the organic field; organic insect control uses BT and pheromone disruption.

The following parameters are measured for all field experiments:
1) Weed population density, measured once in January, and again in July.
2) Olive fly population counts.
3) Leaf spot counts.
4) Olive yield and quality, using a once over harvest of all fruit.
5) Black scale will be assessed by counting the number of scales in 10-cm sections of twig, and number of nymphs on foliage. Age structure of scale will be compared across pruning treatments. Scale feeding will be assessed by counting the percent of leaves with sooty mold accumulations.

Greenhouse experiment:
Olive seedlings will be tested for tolerance to newer herbicides that control problem weeds at very low rates. Three herbicides will be applied to olive seedlings at two rates, the upper and lower limits of those recommended for weed control. The experiment will be a randomized complete block experiment with five replications. Each seedling will be visually rated for injury and height measured 2 and 6 weeks after treatment. After two months, all seedlings will be harvested and dry weight determined.

**f.** **Justification:** Weeds reduce olive yield and quality by competing directly with the plants for light, water, and nutrients. Newly established orchards are especially vulnerable to weed competition, and trees may be killed before they can bear fruit. Weeds also harbor insects and pathogens. Sampling must be extended into November 2002, the normal harvest period for olives in Albania.

There is a rapidly growing market for organic products. Organic products command prices several times higher than for the conventional segment of the market. This would increase competitiveness in the European market. The rules for organic certification require production without the use of synthetic pesticides or fertilizers. Many Albania growers are currently producing crops that would be eligible for organic certification, but the yields are low. Additional research on nitrogen production by cover crops and non-chemical pest management should provide the information needed to boost yields.

**g.** **Relationship to other research activities at the site:** The study, along with the harvest timing and pheromone-based olive fruit fly control experiments, will contribute to developing an organic olive production system.

h. **Progress to date:** Work on this project was initiated in spring, 2000. Orchard blocks have been cultivated and pruned at Shamogjin, a research grove near Vlora operated by Fruit Tree Research Institute. Two types of management were evaluated, an organic production system and one using synthetic pesticides and fertilizers (conventional system). Both systems were established in experimental fields of FTRI. Satisfactory results were obtained with the use of mulching straw including increased productivity of olive trees, avoiding weed competition and conserving soil moisture for longer periods of time. Good results were also obtained using the selective herbicide diuron, reducing weed germination and the non-selective herbicide glyphosate.

i. **Projected outputs:** Refereed publications. Growers will gain new information on vegetation management and organic production.

j. **Projected impacts:** New systems for weed management. Reduced disease and insect populations. Development of new products, organic vegetables, for the export market

k. **Project start:** October 1999

l. **Projected completion:** September 2002

m. **Projected person-months of scientists time per year:** 12 person months

n. **Budget:** $8405 -- Albanian institutions; $0 -- University of California; $0 -- Penn State, $0 -- Virginia Tech.

**II.3** **Title**: Effect of pruning on olive production, infestation by black scale and incidence of olive knot and timing of copper sprays to control olive leaf spot and olive knot.

a. **Scientists**: Z. Veshi, J. Tedeschini, M. Baci, H. Pace, R. Uka, M. Hasani, Sh. Shahini, and M. Baçaj – Albanian institutions; D. Pfeiffer – Virginia Tech; L. Ferguson, B. Teviotdale – University of California

b. **Status:** Finishing third year; project completion

c. **Objectives**: To (1) demonstrate the effect of pruning on yield, black scale infestation and olive knot incidence, and oil quality and (2) determine optimal timing for control of olive leaf spot and olive knot diseases.

d. **Hypothesis:** (1) Greater pruning severity should increase fruiting wood and therefore yield simultaneously reducing the infestation of black scale. However olive knot incidence may increase with greater numbers of pruning wounds which are infection sites for the pathogen. Spray penetration should be improved in trees with more open canopies. (2) Tracking infection events for olive leaf spot and olive knot during the year may help identify superior treatment programs.

e. **Description of research activity:** (1) Pruning experiments: Three levels of pruning severity, 0% (non-pruned), 10-20% (light), and 40-50% (heavy) are tested. Trees are pruned once and treatments applied in January and February. Production of fruiting wood is assessed after six months, one and two years.

Black scale is assessed by counting the number of scales in 10-cm sections of twig, and number of nymphs on foliage. Age structure of scale is compared across pruning treatments. Scale feeding is assessed by counting the percent of leaves with sooty mold accumulations. Olive knot is assessed by determining the number of infected pruning cuts that became infected. Spray penetration is assessed by determining scale mortality after a pesticide application. Water sensitive paper is attached to branches and the density of water droplets will be quantified. Using other trees, copper sprays are applied monthly from October through May. Immediately before application, 30 leaves are collected at random from each tree and tested for latent infections of olive leaf spot. Also, ten pairs of leaves are removed. Twenty 1-yr-old shoots per tree and 20, 2.5 cm diameter shoots are pruned. Natural incidence of olive leaf spot is determined on 20 shoots per trees selected at random on the day of evaluation in summer. Percent infection of the defoliated shoots and pruning cuts are determined in fall. There will be six single-tree replications arranged in a randomized complete block design.

f. **Justification:** In olive groves currently grown in Albania, pesticides are often impractical to apply. Cultural control would be a valuable part of IPM. Differential pruning could allow greater mortality of black scale, decreasing the need to apply sprays. Honeydew production will be decreased in such conditions. As more resources are available to Albanian growers, incorporation of organically acceptable (copper) treatments is expected. Optimal use of these sprays will reduce costs and increase production. This work has been carried out for three years. Sampling must be extended into November 2002, the normal harvest period for olives in Albania.

g. **Relationship to other research activities at the site**: Other research activity on olive growth and insect development will be carried out at Vlore. The increased ease of harvest resulting from this experiment will facilitate early harvest to avoid olive fruit fly infestation.

h. **Progress to date**: Work on this project was initiated in spring, 2000. Orchard blocks have been cultivated and pruned at Shamogjin, a research grove near Vlora operated by Fruit Tree Research Institute. Three levels of pruning severity (non-pruned, lightly pruning and heavily pruning) were tested. Water sensitive papers attached to branches have demonstrated that the density of water droplets were higher in heavy pruning trees and light pruning trees compared with non pruned trees. Spray penetration was improved in trees with more open canopies. Some data indicate that the black scale infestation was reduced in pruning trees. Another experiment was carried out applying treatments with copper fungicides every month (October-May) to determine the best moment of spraying to control leaf spot and olive knot. The results of this year show that the treatments of March and April are more protective. Furthermore, bearing surface is created lower in the tree, facilitating harvest.

i. **Projected outputs**: Research and extension publications will be produced that describe the effects of this cultural practice on scale and olive knot incidence and treatment timing for olive leaf spot. Information will be distributed to growers through normal channels (booklets, seminars, specialist and farmer training).

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

**k.** **Project start:** October 1999

**l.** **Projected completion**: September 2002

**m.** **Projected person-months of scientists time per year**: 12 person months

**n.** **Budget:** $12367 -- Albanian institutions; $3780 -- University of California; $0 -- Penn State; $0 -- Virginia Tech.

**II4.** **Title:** Pheromone-Based IPM in Olive and Effects on Non-Target Species.

**a.** **Scientists**: R. Uka, E. Isufi, J. Tedeschini, M. Baci – Albanian institutions; D. Pfeiffer – Virginia Tech

**b.** **Status:** Finishing third year; project completion.

**c.** **Objective:** To develop a selective attractant-based control system for olive fruit fly, *Bactrocera (Dacus) oleae* (Gmelin), and document its suitability for black scale, *Saisettia oleae* Olivier, biological control.

**d.** **Hypotheses:** (1) Mating disruption can be an effective management tool for olive fruit fly, (2) A minimum block size of 2 ha is required; (3) The pheromone-based program will allow successful biological control of black scale.

**e.** **Description of research activity:** Mating disruption will be used for olive fruit fly. Pheromone will be placed before first flight. Traps will be checked weekly. Fruit damage will be assessed every two weeks. Oil quality will be determined at harvest. Predators and parasites of black scale and other pests will be assessed every two weeks. There will be three treatments: (a) pheromone-based, (b) insecticide, and (c) untreated control.

**f.** **Justification:** Olive fruit fly is the main key pest of olive in Albania. Sprays for this species disrupt biological control of black scale. The latter is considered a very damaging olive pest. Because sprays have not been widely used for several years, most groves now have viable populations of scale parasites and predators, a resource that should be conserved. If a pheromone based program is successful, fly damage will be minimized without sacrificing biological control of black scale. Sampling must be extended into November 2002, the normal harvest period for olives in Albania.

**g.** **Relationship to other research activities:** Pheromone-based management of olive fruit fly will interact with other experiments in fostering an organic management system for olive.

**h.** **Projected outputs:** A series of recommendations will be made on selective IPM, which will be distributed, to growers through the Extension Service and other standard means. Results will also be published in scientific journals.

**i.** **Projected impacts:** A stable IPM program will allow a nontoxic control for two important olive pests, increasing farmer safety. The improved survival of natural enemies will prevent black scale from exceeding the economic threshold. IPM practices will result in lower costs and higher income for farmers.

**j.** **Progress to date:** Work on this project using attract-and-kill technology was initiated in spring, 2000. Orchard blocks have been cultivated and pruned at Shamogjin, a research grove near Vlora operated by Fruit Tree Research Institute. Results have been excellent, with high degree of control provided. On untreated experimental field the levels of fruit infestation was relatively high whilst the olive fruit fly infestation where eco-traps were used the level remained low. At the harvest time in November only 5 – 6 % of the olive fruits were infested. In the olive groves protected with one insecticide spray, the infestation reached about 20 %. An alternative pheromone-based tactic is mating disruption; this has not been tried in Albania.

**k.** **Starting date:** 1 October 1999

**l.** **Ending date**: 31 September 2002

**m.** **Scientist-months per year:** 10

**n** **Budget:** $14001 -- Albanian institutions; $0 -- Penn State; $0 -- University of California; $0 -- Virginia Tech

## III. Socioeconomic analyses

### III.1 Understanding the Price and Marketing for Olives in Albania and other Mediterranean countries

**a.** **Scientists:** M. Bregasi, G. Norton, Dan Taylor

**b.** **Status:** Finishing third year; project completion

**c:** **Objective:** To understand the markets and potential markets for olives in the Mediterranean area and by analysis determine potential niche markets.

**d.** **Hypothesis:** Potentially profitable markets exist for Albanian olives

e. **Description of research activity:** These activities will be conducted by CIRA which will devote its own resources to gathering information and analyzing the nature of the markets for Albanian olives

f. **Justification:** Market conditions, including prices and export potential, are drivers of crop choice and pest management decisions. Understanding the role of prices and export demand in influencing crop choice is necessary for targeting IPM practices and developing priority areas for research.

g. **Relationship to other research activities at the site:** Only indirect relationships, but these results will provide economic motivation for adoption of other results.

h. **Progress to date:** New

i. **Projected outputs:** Papers and presentations to research community and policy makers

j. **Projected impacts:** (1) Improved understanding of what drives crop choice and pesticide use; (2) Improved targeting of research and policy interventions.

k. **Project start:** October 1999

l. **Projected completion:** September 2002

m. **Projected person-months of scientists time per year:** 3

n **Budget:** $0 -- Albanian institutions; $0 -- Virginia Tech.

### III.2 Project Economic Impacts of Albania IPM CRSP Research Activities

a. **Scientists:** L. Daku (Albanian graduate student and faculty member at AUT), M. Bregasi, D. Taylor and G. Norton – Virginia Tech

b. **Status:** Project completed

c. **Objectives:** To (1) Evaluate and forecast economic impacts resulting from pest management strategies (PMS) on olives developed by the IPM CRSP Albania; (2) Design a system for assessing impacts in other IPM programs in Albania

d. **Hypothesis:** (1) IPM practices will result in higher income for farms that adopt IPM; (2) IPM practices will generate economic benefits to Albanian society as a whole.

e. **Description of research activity:** Economic budgets incorporating production costs and financial returns will be developed for IPM components and packages. IPM packages will be assessed regarding their requirements of farm resources such as land, labor, and cash at specific times in the agricultural calendar. Economic surplus analysis will be used to project national-level impacts of IPM adoption. A protocol will be developed for use in future IPM impact assessments in Albania.

f. **Justification:** Knowledge regarding the farm-level profitability of IPM strategies is necessary for promoting IPM and predicting likely patterns of adoption. Knowledge regarding potential aggregate social benefits of IPM adoption is necessary for informing national policy makers and research directors of the overall merits of IPM strategies and their economy-wide impacts. Information can also be used to develop specific policies to encourage IPM adoption. Technology transfer to other settings requires information regarding the likely settings in which adoption is expected to occur.

g. **Relationship to other research activities at the site:** This work specifically addresses issues related to the profitability of IPM strategies being developed by other IPM CRSP scientists.

h. **Progress to date:** With the results of the doctoral program of Lefter Daku, this project is complete. The following surveys were conducted: Expert surveys on (i) potential aggregate economic benefits of olive IPM CRSP/Albania project's research activities, (ii) the actual and preferred ranking of priorities given in plant protection in Albania, and (iii) factors influencing pesticide use in Albania. Expert judgments were elicited by interviewing twenty Albanian researchers from Agricultural University of Tirana (AUT), Plant Protection Research Institute (PPRI) Durress, Fruit Tree Research Institute (FTRI) Vlore, and Ministry of Agricultural and Food (MOAF), Tirana. The expert judgment elicitation process was based on the Stanford/SRI Assessment Protocol, which consists of the following steps: motivating, structuring, conditioning, encoding, and verifying. Sixty questionnaires were completed for the three expert surveys. A follow-up survey to evaluate factors affecting prospects of farmers' adoption of olive IPM practices developed by IPM CRSP/Albania project. Farmers' interviews were conducted from Saturday, July 1st through Thursday, July 6th. Both male and female farmers were included in the survey. The team was made up of 9 research scientists: 7 from FTRI, one from PPRI, and one from Virginia Tech, USA. Interviews were conducted in the following Vlora villages: Cerkovine, Bestrove, Kanine, Panaja, Tre Vellazen. Overall, 120 questionnaires were completed. The processing of data, which resulted from the above surveys is almost completed. Data from the expert surveys are manipulated and formatted in compliance with the economic surplus model. A representative (baseline) olive enterprise budget has been obtained and partial olive budgets for each project under implementation by IPM CRSP/Albania are being computed to assess the profitability of these projects at the farm level. Some preliminary results with respect to potential economic impacts of pest management strategies on olives developed by the IPM CRSP/Albania have been obtained. However, these results are not available for the moment because they will have to be incorporated into dissertation report entitled: "Assessing Farm-level and Aggregate Economic Impacts of Olive Integrated Pest Management Programs: An Ex-Ante Analysis". Presently, three chapters of dissertation have been submitted as a draft and the remaining chapters will be completed by this fall.

Additionally, data on olive production, prices of olive products, population growth, and pesticide use were collected from secondary sources.

i. **Projected outputs:** The profitability of IPM components and packages will be estimated and reported in papers and presentations to the research community and policy makers in Albania

j. **Projected impacts:** Better decision making among researchers and policy makers regarding appropriate IPM technologies and likely on-farm impacts.

k. **Project start:** October 1999

l. **Projected completion:** September 2002

m. **Projected person-months of scientists time per year:** 3

n. **Budget:** $0 – Albanian institutions; $0 – Virginia Tech

INTEGRATED PEST MANAGEMENT -- COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), ALBANIAN SITE

| ACTIVITY | | SCIENTISTS | BUDGET ($) |
|---|---|---|---|
| **BASELINE SURVEY AND CROP/PEST MONITORING** | | | |
| I.1 | Meeting the educational and planning needs for Olive Integrated Pest Management | F. Thomaj, M. Bregasi, J. Tedeschini, H. Pace, R. Uka, M. Hasani, B. Stamo, D. Panajoti, B. Ferraj, S. Shahini, B. Huqi, H. Ismaili, Z. Veshi, M. Baci, V. Jovani - Albania Institutions; C. Pitts – Penn State; L. Ferguson, B. Teviotdale, M. McGiffen – University of California; G. Luther, K. Moore, D. Pfeiffer – Virginia Tech | Albania $ 6,881<br>Virginia Tech $ 2,540 |
| I.2 | Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems | F.Thomaj, M. Bregasi, J. Tedeschini, H. Pace, R. Uka, M. Hasani, B. Stamo, V. Jovani – Albania Institutions ; C. Pitts – Penn State; L. Ferguson, B. Teviotdale, M. McGiffen – University of California; D. Pfeiffer – Virginia Tech | Albania $10,117 |
| **MULTIDISCIPLINARY PEST MANAGEMENT EXPERIMENTS** | | | |
| II.1 | Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality | D. Pfeiffer – Virginia Tech; F. Thomaj, M. Bregasi, J. Tedeschini, D. Panajoti, B. Ferraj – Albania Institutions; L. Ferguson – University of California; C. Pitts – Penn State | Albania $33,367 |
| II.2 | Organic Pest and Vegetation Management | J. Tedeschini, B. Stamo, H. Pace, B. Huqi, S. Shahini, D. Panajoti, H. Ismaili, M. Bacaj – Albanian Institutions; M. McGiffen, L. Ferguson – University of California | Albania $ 8,405 |

| | | | |
|---|---|---|---|
| II.3 | Effect of pruning on olive production, infestation by black scale and incidence of olive knot and timing of copper sprays to control olive leaf spot and olive knot. | Z. Veshi, J.Tedeschini, M. Baci, H. Pace, R. Uka, M. Hasani, S. Shahini, M. Bacaj – Albanian Institutions; D. Pfeiffer – Virginia Tech; L. Ferguson, B. Teviotdale – University of California | Albania $12,367<br>U. California $ 3,780 |
| II.4 | Pheromone-Based IPM in Olive and Effects on Non-Target Species | R. Uka, E. Isufi, J. Tedeschini, M. Baci – Albanian Institutions; D. Pfeiffer – Virginia Tech | Albania $14,001 |
| **SOCIOECONOMIC ANALYSIS** | | | |
| III.1 | Understanding the Price and Marketing for Olives in Albania and other Mediterranean countries | M. Bregasi – Albanian Institutions; G. Norton, D. Taylor – Virginia Tech | -0- |
| III.2 | Project Economic Impacts of Albania IPM CRSP Research Activities | L. Daku, M. Bregasi – Albanian Institutions; D. Taylor, G. Norton – Virginia Tech | -0- |

# Degree Training

## Integrated Pest Management
## Collaborative Research Support Program
## (IPM CRSP)

## Annual Workplan

## For Year 10

## (September 29, 2002 to September 28, 2003)

# Degree Training

| Region: Asia | Site Philippines | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Student Name | Sex | Nationality | Discipline | Site / Country | Degree | Start Date | Comp. Date | IPM CRSP Fund | Advisor/ PI | Thesis Topic | University |
| 1 | Jean Recta | F | Philippines | Statistics | Asia/ Philippines | Ph. D. | 8/96 | 8/02 | yes | E. Rajotte | | Penn State |
| 2 | Irene R. Tanzo | F | Philippines | Soc. Science | Asia/ Philippines | Ph. D. | 1/00 | 1/03 | yes | C. Sachs | | Penn State |
| 3 | Edwin C. Martin | M | Philippines | Weed Science | Asia/ Philippines | M.S. | 6/00 | 12/02 | yes | A.Baltazar, L.T. Kok | Biological control of weeds | UPLB/Va Tech |

| Region: South Asia Site: Bangladesh | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Student Name** | **Sex** | **Nationality** | **Discipline** | **Site / Country** | **Degree** | **Start Date** | **Comp. Date** | **IPM CRSP Fund** | **Advisor/ PI** | **Thesis Topic** | **University** |
| **1** | Md Faruque-uz-zaman | M | Bangladesh | Entomology | Bangladesh | M.S. | Jul. 01 | Sep. 03 | 100% | Ed Rajotte | N/A | Penn State |
| **2** | Mossammat S. Nahar | F | Bangladesh | Plant Pathology | Bangladesh | Ph.D. | Jul. 01 | Sep. 03 | 100% | S. Miller | N/A | Ohio State |
| **3** | Nazrul Islam | M | Bangladesh | Weed Science | Bangladesh | Ph.D. | Jun. 01 | Dec. 04 | 100% | A. Baltazar | N/A | UPLB |
| **4** | Sanjiv Mishra | M | Indian | Agricultural Economics | Bangladesh/Philippines | M.S. | Aug 02 | Sep 03 | 100% | G. Norton | IPM Impacts Analysis | Virginia Tech |

## Caribbean Region: Jamaica Site

| No | Student Name | Sex | Nationality | Discipline | Site / Country | Degree | Start Date | Comp. Date | IPM CRSP Fund | Advisor/ PI | Thesis Topic | University |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | M. Schroeder | M | U.S.A. | Entomology | Jamaica | | | | 0% | C. Edwards | | Ohio State |
| 2 | B. Lovett | M | U.S.A. | Entomolog | Jamaica | M.S. | Aug.02 | May04 | Partial | S. Fleischer/L.Cui | Molecular probes for gall midge taxonomy | Penn State |
| 3 | K. Dalip, 1 other | F | Trinidad | IPM Technologies | Jamaica | Non-degree | Oct. 02 | Aug03 | 100% | S. Fleisher | Molecular biology techniques for insect or pathogen diagnosis | Penn State |
| 4 | J. Goldsmith | F | Jamaican | Entomology | Jamaica | Non-degree | Oct. 02 | Aug03 | 100% | C. Edwards | Acarology taxonomy | Ohio State |
| 5 | To be named | ? | ? | Weed Management | Jamaica | M.S./Ph.D. | Oct. 02 | Sept.04 | Partial | To be named | Weed Science | Penn State or Virginia Tech |
| 6 | To be named | ? | ? | IPM Technologies | Jamaica | Non-degree | Oct. 02 | Sept.03 | 100% | To be named | Information Technologies of IPM | Penn State |

## Region: West Africa Site: Mali

| No | Student Name | Sex | Nationality | Discipline | Site / Country | Degree | Start Date | Comp. Date | IPM CRSP Fund | Advisor/ PI | Thesis Topic | University |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Bright Abonuhi | M | Ghanaian | Ag Economics | Mali | M.S. | 9/01 | 6/03 | 100% | A. Yeboah | Analysis of IPM Profitability | **NCAT** |
| **2** | Moussa Noussourou | M | Malian | Entomology | Mali | Ph.D. | 9/01 | 9/03 | 100% | R. Foster | IPM for Hibiscus | **University of Mali/Purdue** |
| **3** | Safiatou Dem | F | Malian | BioChemistry | Mali | M.S. | 8/02 | 6/04 | 100% | D. Mullins | Pesticide Residues in Ground Water | **Virginia Tech** |
| **4** | Sidiké Traoré | M | Malian | Entomology | Mali | D.E.A. | 1/02 | 9/03 | 100% | K. Gamby | Entomology of Green Beans | **University of Mali** |
| **5** | Daouda Dembélé | M | Malian | Weed Science | Mali | D.E.A. | 9/02 | 9/03 | 100% | B. Dembélé | Striga Resistance in Sorghum | **University of Mali** |

**Region : Eastern Africa UGANDA SITE**

| No | Student Name | Sex | Nationality | Discipline | Site/Country | Degree | Start date | Comp. Date | IPM CRSP fund | Advisor/PI | Thesis Topic | University |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | G. Lubadde | M | Ugandan | Crop Science | Uganda | MSc. C. Science | 09/01 | 09/03 | 100% | Dr. A. Kangire | Significance of infected planting materials in transmission of coffee wilt disease and alternative hosts for *Fusarium xylarioides* | Makerere University |
| 2. | A. Wasukira | M | Ugandan | Crop Science | Uganda | MSc. C. Science | 09/01 | 09/03 | 100% | Dr. G. Hakiza | Determination of infection avenues and the establishment of *Fusarium xylarioides* within coffee tissues | Makerere University |
| 3. | T. Munyuli | M | Congolese | Environment and Natural Resources | Uganda & DRC | MSc. Environment and Natural Resources | 10/01 | 10/03 | 50% | Dr. S. Kyamanywa/ R. Hammond | Species diversity of anthropod indigenous natural enemies of cowpea and groundnut pests in Uganda and DRC and their impact on pest population. | Makerere University |
| 4. | M. Amujal | F | Ugandan | Agriculture Extension | Uganda | MSc. Agriculture Extension | 10/01 | 10/03 | 50% | Drs. M. Erbaugh/A. Semana | Factors affecting the adoption of IPM practices by cowpea farmers in eastern Uganda | Makerere University |
| 5. | B. Mugonola | M | Ugandan | Agriculture Economics | Uganda | MSc. Agriculture Economics | 10/00 | 10/02 | 100% | Drs. V. Kasenge, B. Bashaasha & D. Taylor | Price Risk & IPM technology consideration in supply analysis - a case of cowpea in eastern Uganda | Makerere University |
| 6. | E. Kagezi | M | Ugandan | Crop Science | Uganda | MSc. Crop Science | 10/00 | 10/02 | 100% | Drs. S. Kyamanywa, C. Akemo & R. Hammond | Damage yield relationships of major pests of tomatoes in central Uganda | Makerere University |
| 7. | J. Bonabana | F | Ugandan | Agriculture Economics | Uganda & VT | MSc. Agriculture Economics | 08/00 | 12/02 | 100% | Prof. D. Taylor, Dr. V. Kasenge | Socio-economic assessment of IPM CRSP technology development activities in Uganda | Virginia Tech |
| 8. | G. Asea | M | Ugandan | Crop Science | Ohio | Ph. D | 8/01 | 8/05 | 100% | Profs R. Pratt, P. Lipps, & A. Ekwamu | Resistance Gene Pyramiding Using molecular-assisted selection to enhance sustainable maize production in Uganda | Ohio State University |
| 9. | A. N. Kaaya | M | Ugandan | Food Science | Uganda & VT | Ph.D. | 8/02 | 6/03 | 100% | H. Warren | | Makerere University |
| 10. | A. Alumai | M | Ugandan | Crop Science | Ohio | MSc. Crop Science | 10/01 | 10/03 | 30% | Drs. Grewal, Hammond & Kyamanywa | Bio-diversity of entomopathogenic nematodes in Ohio and Uganda | Ohio State University |
| 11. | H. Opolot | M | Ugandan | Crop Science | Uganda | MSc. Crop Science | 10/01 | 10/03 | 50% | Drs. S. Kyamanya & A. Agona | Integrated management of Aphids, Thrips, Pod suckers & Bruchids on cowpea suing selected synthetic & Botanical pesticides | Makerere University |
| 12. | G. Sseruwu | M | Ugandan | Crop Science | Uganda | MSc. Crop Science | 10/01 | 10/03 | 50% | Dr. G. Bigirwa | Maize variety evaluation for ear rots resistance and identifying suitable innoculation method for ear rots in highlands and mid-altitudes of Uganda | Makerere University |

| Region: Central America | | | Site: Guatemala | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Student Name** | **Sex** | **Nationality** | **Discipline** | **Site / Country** | **Degree** | **Start Date** | **Comp. Date** | **IPM CRSP Fund** | **Advisor/ PI** | **Thesis Topic** | **University** |
| **1** | **Carlos Mayen** | **M** | **Guatemala** | **IPM** | **C.A./ Guatemala** | **M.S.** | **Aug. 00** | **May 03** | **50% 50%GO G** | **S. Weller** | **Weed Mgmt** | **Purdue** |
| **2** | **Jim Julian** | **M** | **USA** | **Mktg/Econ** | **C.A./ Guatemala** | **Ph.D.** | **May 99** | **Jan. 03** | **100%** | **G. Sullivan** | **International Trade** | **Purdue** |

| Region: South America | | | Site: Ecuador | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Student Name** | **Sex** | **Nationality** | **Discipline** | **Site / Country** | **Degree** | **Start Date** | **Comp. Date** | **IPM CRSP Fund** | **Advisor/ PI** | **Thesis Topic** | **University** |
| **1** | **Carolina Baez** | **F** | **Ecuador** | **Agri. Econ** | **Ecuador** | **MS** | **8/02** | **6/04** | | **Alwang** | **Economic Impacts of Andean Fruit IPM** | **VA Tech** |
| **2** | **Sandra Garces** | **F** | **Ecuador** | **Entomology** | **Ecuador** | **MS** | **1/02** | **9/03** | | **Williams** | **IPM on Potato Pests** | **Ohio State** |
| **3** | **Giovanni Suquillo** | **M** | **Ecuador** | **IPM** | **Ecuador** | **MS** | **10/01** | **6/03** | | **Lagnaoui, Gallegos** | **Biocontrol of Central American Tuber Moth** | **U. of Ecuador** |

| Region: Eastern Europe Site: Albania | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Student Name** | **Sex** | **Nationality** | **Discipline** | **Site / Country** | **Degree** | **Start Date** | **Comp. Date** | **IPM CRSP Fund** | **Advisor/ PI** | **Thesis Topic** | **University** |
| **1** | **N/A** | | | | | | | | | | | |
| **2** | | | | | | | | | | | | |

# Proposed International Travel Schedule
# For IPM CRSP Year 10 Work Plan

## International Travel Table for IPM CRSP: Year 10

### Asian Site in the Philippines- Year 10 expected travel

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 7 | Philippines | 7-10 days, Jan/Feb 2003 | Review research progress, research planning, farmer field visits |
| 2 | 1 | New Zealand (from Philippines) | 7-10 days, Feb 2003 | Presentation of IPM CRSP research results at International Congress of Plant Pathology |
| 3 | 4 | U.S. (from Philippines) | 1 week, April, 2003 | Participate in planning workshop and symposium at Indianapolis |
| 4 | 2 | Philippines | 1 week, April/May 1003 | Research review and planning |
| 5 | 4 | U.S. (from Philippines) | 2 months | Short-term training |

*Proposed dates may change depending on changing circumstances

## Asian Site in Bangladesh- Year 10 expected travel

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 8 | Bangladesh | 1 week, late January 2003 | Review research progress, research planning, farmer field day |
| 2 | 4 | U.S. (From Bangladesh) | April, 2003 1 week | Participate in planning workshop and symposium at Indianapolis |
| 3 | 2 | Bangladesh | 1 week, late September | Research review and planning |
| 4 | 1 | Taiwan (From Bangladesh) | 2 months | Short-term training |
| 5 | 1 | Philippines (From Bangladesh) | 2 weeks | Short term training |
| 6 | 2 | U.S (From Bangladesh) | 2 weeks | Short term training |

*Proposed dates may change depending on changing circumstances

## Caribbean Site in Jamaica

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1-2 | 1 (Tolin) | Jamaica, other CARDI sites | 5-7 days each | Site chair research oversight and coordination, work plan development |
| 3 | 1 (site chair) | Caribbean | 1 week | PROCARIBE interaction meeting |
| 4 | 1 (Tolin) | New Zealand | 1 week | International Plant Pathology meeting and networking |
| 5 | 2 (Fleisher, other) | Jamaica | Spring, summer 2002 – 1 week | Research collaborations for vegetable IPM and Web GIS; Work plan review. |
| 6 | 2 (Edwards) | Jamaica | Spring 2002 – 1 week | Research collaborations on broad mite, pesticides and biocontrol; Workplan review. |
| 7 | 1 (Jackson) | Jamaica, Antigua, St. Kitts | Fall 2002 and Spring 2003 - 3 trips, 4-6 days | Research collaboration on sweetpotato IPM; Regionalization of IPM to other Caribbean nations |
| 8 | 2 (Momson, Harris) | Jamaica | October 2002 | Socioeconomic and gender analyses |
| 9 | 1 Momson) | Eastern Caribbean | Spring 2003 – 2 weeks | Gender analyses and marketing |
| 10 | Tolin | Peru, Ecudor | Dec to Feb – 1 week each | Collaborative research planning with CIP; Central American IPM-CTSP site in Ecudor |
| 11 | 3 trainees | U.S. (From JA) | 1-2 wks | Short Term Training on Biotech and taxonomic methods |
| 12 | 2 (D. Clarke-Harris & S. Fleischer) | Trinidad, Barbados | October 2002 – 10 days | Research collaborations with local personnel |
| 13 | 2 (D. Clarke-Harris & S. Fleischer) | Trinidad, Barbados | April 2003 – 10 days | Research collaborations with local personnel |
| 14 | 2 (D. Clarke-Harris & S. Fleischer) | France | October 2002 – 6 days | Diamond-back moth workshop |

| | | | | |
|---|---|---|---|---|
| 15 | 1 (KM Dalip) | St Vincent, St Kitts | October 2002 – 10 days | Research collaboration on sweetpotato IPM |
| 16 | 2 (D Jackson & KM Dalip ) | Peru | November 2002 – 7 days | Training and exposure to fungal (*Beauveria* sp.) biological control |
| 17 | 2 (KM Dalip & other) | St Vincent and the Grenadines, Antigua | March 2003 | Research collaboration on sweetpotato IPM; Regionalization of IPM to other Caribbean nations |
| 18 | 1 (KM Dalip) | St Vincent and the Grenadines, Antigua, St Kitts and Nevis | June 2003 – 15 days | Research collaboration on sweetpotato IPM; Regionalization of IPM to other Caribbean nations |
| 19 | 2 (Jamaican) | U.S. (from Jamaica) | 1 week – May 2002 | IPM CRSP Technical Committee and planning meeting |
| 20 | Tolin | Beltsville MD; Raleigh NC | August 2003 | Consultation on virus testing methods in sweet potato |
| | | | | |

*Proposed dates may change depending on changing circumstances

## West Africa Site in Mali

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 0 | 1 (Moussa Noussourou | USA | July – December 2002 | Semester at Purdue, sandwich program |
| 1 | 1 (Florence Dunkel) | Mali | 2 weeks in late October-early November | Research collaboration to complete outstanding papers |
| 2 | 1(Jim Westwood) | Mali | 1 week in November | Field observations, research collaboration, and planning |
| 3 | 1 (Keith Moore) | Mali, France | 3 weeks in Nov. /Dec. | Exporter meeting and market analysis |
| 4 | 1 (Willie Sanchez) | Mali | 2 weeks in November | Exporter meeting, market and regulatory analysis |
| 5 | 1 (Halima Traoré) | France | 2 weeks in Nov./Dec. | Laboratory and regulatory service meetings |
| 6 | 3 (Don Mullins, Jean Cobb, Pat Hipkins) | Mali | 3 weeks in December-January | Training, field observations and participatory assessment |
| 7 | 1 (Rick Foster and Bob Gilbertson) | Mali | 2 weeks in January | Paper development and research collaboration |
| 8 | 1 (Colette Harris) | Mali | 3 weeks in February | Training and research collaboration |
| 9 | 1 (Keith Moore) | Mali | 2 weeks in March-April | Research collaboration and consolidation of Phase II |
| 10 | 3(Kadiatou Gamby, Haoua Sissoko,Penda Sow) | USA | 2 weeks in May | Site Planning, research collaboration, and training |
| 11 | 1 (Safiatou Berthé) | Mali | 2 weeks in June | Research collaboration and field observations |
| 12 | 1 (Colette Harris) | Mali | 2 weeks in July | Training and research collaboration |
| 13 | 2 (Traoré, Diallo) | USA | 3 weeks in July | Laboratory training |

*Proposed dates may change depending on changing circumstances

## Eastern Africa Site in Uganda

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 1 (Hammond, OSU) | Uganda | 10 days September/October, 2002 | To attend symposium and initiate on-farm trials for second season. |
| 2 | 1 (Ivey, OSU) | Uganda | 8 days Sept./Oct., 2002 | To attend symposium and present coffee wilt characterization findings. |
| 3 | 4 (Warren, Taylor VT, Erbaugh, OSU; Kyamanywa, MU) | Uganda, Kenya, Tanzania, Ethopia | 12 days 11/5- 11/17, 2002 | Annual Report preparation, coffee wilt research implementation, adoption survey, and symposium proceedings. Regionalization development. |
| 4 | 1 (Uganda grad student to be named) | USA | 3 months – 1/03 | Confirmation trials of GLS inoculation techniques. |
| 5 | 1 ( A. Roberts, VT) | Uganda | 10 days (2/03) | Conduct follow-up GIS workshop. |
| 6 | 1 (Bonabana,VT) | Uganda | December, 2002 | Return home following completion of M.S. thesis. |
| 7 | 2 (Alumai/Grewal, OSU) | Uganda | 12 days 12/02 –1/03 | Entomopathogenic nematodes on tomato trials. |
| 8 | 7 (Taylor, Warren, Brhane,VT; Erbaugh, Pratt, Hammond OSU; Mbata, FVSC) | Uganda, Kenya | 12 days, late Feb. early March, 2002 | Annual work plan development meeting, data analysis |
| 9 | 2 (Kyamanywa, Bigirwa, MU/NARO) | USA | 7-10 days, May, 2003 | Attend annual IPM CRSP meetings. |
| 10 | 1 (Pratt, OSU) | Kenya, Uganda | 14 days, May, 03 | Attend International Maize Symposium in Nairobi. |
| 11 | 1 (Luther, VT). | Uganda | 21 days, late May, 2003 | Beneficial insects of cowpea and groundnuts. |
| 12 | 1 (Kaaya, VT) | Uganda | June, 2003 | Return to Uganda to complete doctoral program. |
| 13 | 2 (Taylor, VT, and Erbaugh, OSU) | Uganda | 12 days, late June-September, 2003 | Project Completion. |

*Proposed dates may change depending on changing circumstances

## Site in Central America

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 1 | Guatemala / Honduras | 10 days - October 02 | Program planning and development, research collaborator meetings, site visits; and regional expansion meetings |
| 2 | 4 | Guatemala | 10 days - December 02 | Research collaboration meetings and field data collection |
| 3 | 1 | Honduras | 3 days – Jan-Feb. 03 | Site planning and research review |
| 4 | 1 | Guatemala | 10 days – March 03 | Site planning and research |
| 5 | 1 | Guatemala | 10 days - May 03 | Research work with collaborators, field data collection, new workplan finalization, annual reports discussion |
| 6 | 1 | United States | 5 days – May 03 | T.C. meeting |
| 7 | 3 | Guatemala | 10 days –Jun 03 | Site planning and research, IPM symposium |

*Proposed dates may change depending on changing circumstances

**South American Site in Ecuador**

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 1 | Ecuador | September, 1 week | Research Collaboration |
| 2 | 2 | Ecuador | October, 1 week | Research Collaboration and Site Planning |
| 3 | 3 | Ecuador | October, 10 days | Research Collaboration |
| 4 | 1 | Ecuador | January, 3 weeks | Research Collaboration |
| 5 | 1 | Peru | January-February, 2 months | Completing research for masters degree at CIP |
| 6 | 1 | Ecuador | February, 2 weeks | Research Collaboration |
| 7 | 2 | Ecuador | March/April, 1 month | Research Collaboration & Planning |
| 8 | 2 | USA | May, 1 week | Planning workshop |
| 9 | 1 | Ecuador | Summer, 1 month | Research Collaboration |

*Proposed dates may change depending on changing circumstances

**Site in Eastern Europe Albania**

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 2 (Albanian Co-PIs) | USA | One trip in May, 1-1.5 weeks | Albanian scientists to attend CRSP planning workshop held in Blacksburg |
| 2 | 2 (Albanian Co-PIs) | Italy | 1 week | Participate in International Organization of Biological Control conference |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

*Proposed dates may change depending on changing circumstances

**Management Entity**

| *Trip No.* | *Number of individuals* | *Destination country(ies)* | *Duration and proposed dates** | *Function (site planning, workshop, symposium, etc.)* |
|---|---|---|---|---|
| 1 | 2 | Mali / Uganda | 1 week each country in November / January | Review research activities, work plan development |
| 2 | 2 | Mali | 1 week in August / September | Review research progress |
| 3 | 2 | Bangladesh / Philippines | October / January | Review research activities, Administrative issues |
| 4 | 1 | Bangladesh | 1 week in May / June | PL 480 follow up, administrative and research issues |
| 5 | 3 | Guatemala | December/February | Review research activities |
| 6 | 3 | Ecuador | January / September | Review research activities |
| 7 | 2 | Caribbean | June | PROCICARIBE Regional IPM network TC meeting |
| 8 | 2 | US | May | TC Meeting |

*Proposed dates may change depending on changing circumstances