Integrated Pest Management
Collaborative Research Support Program
(IPM CRSP)

Annual Workplan
for Year Nine
(September 29, 2001 to September 28, 2002)

September 25, 2001 Final Version

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University of Maryland **-** Eastern Shore
North Carolina A&T University
Fort Valley State University

Host Country Institutions

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

International Centers

AVRDC - Taiwan
CIAT - Columbia
CIP - Peru
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IRRI - Philippines
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Private Sector

The Kroger Company
PICO
Caito Foods

NGOs/PVOs

CLADES; GEXPRONT,Guatemala; CARE,Bangladesh

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Ninth Year IPM CRSP Annual Workplan

(September 29, 2001 – September 28, 2002)

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 Nine Plan in Perspective

Year nine marks the fourth year of the second five-year phase of the IPM CRSP. The program completed year eight with eight prime sites (The Philippines, Guatemala, Jamaica, Mali, Uganda, Ecuador, and Bangladesh, and Albania) fully operational, with the core funding for the Albania site provided by the USAID mission (funds run through the Global Bureau. A symposium 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 eight. 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 8 and in a special document prepared by the IPM CRSP entitled IPM CRSP Highlights.

Year nine research activities reflect an expanded effort in biotechnology related to IPM. 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 Ninth 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 ten. A technical committee meeting will be held immediately before and after the symposium workshop to assess technical progress, critique workplans and discuss technical issues common across sites. This workshop will be held at Virginia Tech or Ohio State

2. Globalization

Several globalization activities will be undertaken during year 9. First, the book chapters presented at the IPM CRSP symposium in May 2001 will be revised and expanded with a plan to move the manuscript off to a press in early 2002 and a publication later in the year. 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 nine 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 several regions, are just some of the activities planned in this area.

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 nine, 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.

Prepare Tenth Year Workplan

The Tenth year workplan will be prepared and revised following AID review.

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 2002

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.

Ninth Year Workplan for the Southeast Asian Site in the Philippines

Research, extension and training activities planned for Year 9 at the Asia site in the Philippines continue to focus on developing environmentally and economically sound approaches to manage pests in rice-vegetable cropping systems, with focus on onion and eggplant grown after rice. Research studies to determine both immediate and long-range solutions to the most critical pest problems are conducted through: (1) multidisciplinary on-farm studies; (2) multidisciplinary laboratory, greenhouse, and microplot studies; (3) socio-economic impact analysis, and (4) IPM technology transfer and feedback. The activities, integrated among the various disciplines (entomology, plant pathology, weed science, nematology, sociology, economics) address a broad range of IPM strategies from validating endogenous farmers' cultural practices to chemical, biological, or genetic methods. While most studies employ a single crop approach (vegetables only), multi-crop approaches are used on pests that appear in both rice and vegetable crops. Most of the experiments are continuing studies that confirm or build up on results of studies conducted from Years 1-8, some are new studies on newly emerging pests or on new pest management approaches. Cooperation between the Philippine and Bangladesh sites on management of eggplant pests using genetic and cultural approaches will be continued. To encourage participation of farmers in the IPM approach as well enhance interaction between researchers and farmers, the field studies are conducted in farmer cooperators' fields and at a site donated by NOGROCOMA, an onion growers' cooperative in Northern Luzon. Socio-economic impact analyses are an integral part of each study and relevant economic data are collected for each study.

From results of completed studies, promising technologies will be identified and integrated into the IPM training programs of the PhilRice Extension and Training Division as part of the Technology Transfer and Feedback activity. The training programs are targeted to training of trainers (provincial level) who will in turn train agricultural technicians (municipal level). Mature technologies will also be shown in techno-demo plots in village level integration studies to be conducted in pilot areas. IPM CRSP-supported scientist training will also continue in Year 9, with a graduate student each in Statistics and Sociology at Pennsylvania State University, economics at Virginia Tech, and weed science at the University of the Philippines Los Banos. The weed science graduate student will undergo a 3-month training program on biological control of weeds at Virginia Tech.

The IPM CRSP team at the Philippine site is composed of scientists from PhilRice (lead institution), University of the Philippines Los Banos, Central Luzon State University, Visayas State College of Agriculture, from international institutions (International Rice Research

Institute, Asian Vegetable Research and Development Center) and from U.S. universities (Ohio State University, Pennsylvania State University, Virginia Tech and Tuskegee University). This collaboration of national and international scientists provides a perfect complementation of rice and vegetable expertise in the various IPM disciplines in entomology, weed science, plant pathology, nematology, economics and sociology.

I. 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 9 Objectives: (**1) Identify the best combination of tillage and chemical control methods in stale-seedbed techniques with or without rice hull burning 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.*

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. Plot 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.

Selective post-plant applications of glyphosate. The study will be conducted in Bongabon, Nueva Ecija, where onion is grown in rows on raised furrows. Promising treatments identified from Yr 8 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 a 0.5 x 0.5 m quadrat 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:

<u>*Stale-seedbed technique:*</u> Studies on two cycles of the rice-onion rotation have been completed in an onion field where rice straw mulching is a traditional cultural practice. Mechanical or chemical stale seedbed treatments once or twice in the rotation cycle decreased tuber and shoot densities over time by 86 to 90%. Handweeding costs also decreased by 50 to 95% while crop yields and net incomes increased over time by 56 to 91%. Total net incomes from stale seedbed treatments were $1,000 more than income from farmer's practice and $2,500 more than income from unweeded plots.

<u>*Selective post-plant application of glyphosate*</u>: 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.

i. Projected outputs: (1) <u>Stale-seedbed technique</u>**:** (a) Identification of optimal combinations of mechanical and chemical weed control methods in reducing tuber populations; (b) Examination of tuber dynamics of *C. rotundus* in rice-onion cropping systems in the tropics; (c) Reduced handweeding labor inputs. (2) <u>Post-plant glyphosate application</u>**:** (a) Increased herbicide selectivity and efficacy against *C. rotundus*; (b) reduced chemical and cultural inputs.

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

k. Projected start: October 1, 1999

l. Projected completion: September 30, 2002

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

n. Budget: PhilRice **-** $5830; Virginia Tech - $3193

I.2 Seasonal Abundance and Economic Importance of the Leafminer, *Liriomyza* sp., in Rice-Onion Cropping Systems

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

b. Status: Continuing activity

c. Overall Objective: To determine the economic importance of *Liriomyza trifolii* in onion. **Year 9 Objectives**: (1) Determine seasonal abundance of *L. trifolii* in a rice-onion cropping system; (2) Develop a visual rating scale for damage caused by *L trifolii*; (3) Determine population dynamics in sprayed and unsprayed fields; (4) Determine level of damage and yield loss relationships.

d. Hypothesis: Not all plant feeding insects cause economic injury to the plant. Understanding the population fluctuations, the factors causing it, and the nature of leafminer damage would lead to a sound pest management strategy. Leaf miner may not be that important as perceived by farmers.

e. Description of research activity: A field planted to 30-day old onion seedlings will be divided into three main plots, each representing a replicate. Each main plot will be further subdivided into 10 subplots, each measuring 2 x 5 m. Weekly sampling will start at 2 weeks after transplanting (WAT) by randomly collecting 10 plants per subplot (for a total of 30 plants) to be brought to the laboratory for data collection and recording. The following information from each plant will be recorded: number of oviposition punctures, eggs, larvae, and damaged leaves caused by leaf miner. Immature stages of the leaf miner will be reared in the laboratory to determine level of mortality due to parasitoids. This will be done both for sprayed and unsprayed fields.

To estimate adult abundance in the area, four yellow board traps (16 x 16 cm, placed 60 cm above ground) will be installed on each side of the field and two inside the plot. Trap catches will be counted and recorded weekly from transplanting to harvest.

f. Justification: Since leaf miner is a recent introduction to the Philippines, there is very limited information available to researchers and farmers about this pest. The effect of its damage to the onion plant should be quantified to determine if farmers practice of repeated insecticide application is warranted. Factors responsible for the population fluctuation will be evaluated to determine its impact on the pest. In addition, the relationship between damaged leaves and yield will be examined.

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 a sound pest management system.

h. **Progress to date:** The species of leaf miner attacking onion in Central Luzon, Philippines was identified *as Liriomyza trifolii* (Burgess).

i. **Projected outputs:** Knowledge of the seasonal abundance of leaf miner, population dynamics in sprayed and unsprayed fields, development of a damage rating scale and damage and yield loss relations hips.

j. **Projected impact:** Reduced insecticide application against leaf miner in onion.

k. **Projected start:** October 1, 2000

l. **Project completion**: September 30, 2002

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

n. **Budget**: PhilRice - $5,390; 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, S.E. Santiago – PhilRice; S.A. Miller – Ohio State

b. **Status:** Continuing activity

c. **Overall Objective:** To develop eggplant cultivars with resistance to bacterial wilt. **Year 9 Objectives**: (1) Evaluate the effectiveness of various rootstocks in reducing bacterial wilt of popular eggplant varieties in two locations (Nueva Ecija and Pa ngasinan); (2) Determine the effect of grafting on yield.

d. **Hypothesis:** Grafting of resistant cultivars of eggplant will further decrease the incidence of bacterial wilt of eggplant in the field, resulting in higher yields.

e. **Description of research activity:** Eggplant cultivars known to be resistant to bacterial wilt (*Ralstonia solanacearum*) will be grafted for use as rootstocks to high yielding but bacterial wilt susceptible varieties of eggplant, including a popular variety widely used by Philippine farmers. Grafting will be done at PhilRice using technology from IPM CRSP Bangladesh site. One-month-old grafted and non-grafted eggplant seedlings will be transplanted into naturally infected farmer's fields in Nueva Ecija and Pangasinan in cultivated and mulched plots measuring 4 x 5 m^2 and arranged in RCBD with four replications. Incidence of bacterial wilt will be monitored in each plot at weekly intervals.

f. **Justification:** Bacterial wilt, caused by *Ralstonia solanacearum*, is a destructive disease affecting solanaceous crops in tropical, subtropical and even in temperate regions of the world. The pathogen is soil-borne and can survive in the deeper layers of the soil, in the rhizosphere and in roots of resistant and non-host plants. The use of resistant varieties in combination with cultural management, e.g. grafting onto wilt -resistant rootstock, can further reduce the incidence of bacterial wilt of eggplant in the field.

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:** The suitability of grafting techniques developed in AVRDC and Bangladesh to manage bacterial wilt was studied using local materials. Ongoing studies are aimed at refining the technique to increase efficiency of the grafting process and to include more cultivars in the evaluation process.

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

j. **Projected impact:** Lower incidence of bacterial wilt and higher yields.

k. **Projected start:** October 1, 1999

l. **Projected completion:** September 30, 2002

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

n. **Budget:** PhilRice - $8,085; OSU $2,709

I.4 Combined Resistance of Eggplant, *Solanum melongena*, to Leafhopper *Amrasca biguttula* Ishida and Eggplant Borer, *Leucinodes orbonali* Guenee

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

b. **Status:** Continuing activity

c. **Overall Objective:** To develop eggplant populations with combined resistance to *Amrasca biguttula* and *Leucinodes orbonalis.* **Year 9 Objectives: (**1) Continue to screen and confirm year 8 results of selected eggplant cultivars in unreplicated trials; (2) Conduct replicated trials at UPLB and PhilRice; (3) Screen crosses obtained from Year 8 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; (2) The mechanism of resistance of eggplant against leafhopper is a combination of antixenosis, antibiosis and tolerance; (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. They will be planted in three 1 m row plots (unreplicated) durin g the regular screening trial. The 22 selected entries for the replicated yield trial will be planted in five 5 m row plots in three replications. All the entries will be rated for bacterial wilt and phomopsis blight.

f. **Justification:** While leafhopper w as observed to cause significant yield loss at early vegetative stage of eggplant, 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 and cause significantly heavy losses or even total crop yield loss. Screening leafhopper varieties for resistance to the eggplant borer is the first attempt to identify and develop eggplants with combined resistance against these two major insect pests. The use of resistant varieties would also help minimize yield loss. It is also environmentally friendly because the use of resistant varieties prevents adverse effects on non-target organisms, enhances establishment of parasites and predators, and thus a safer alternative to heavy pesticide use.

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

h. **Progress to date:** Improved IPB lines, IPB-GSI and IPB GS2 which were developed at the Institute of Plant Breeding at UPLB in 1987 were included in the screening trials and will be included as one of the entries for hybridization work. Several accessions from NPGRL screenings since 1997 were included in the field screening and 15 entries showed moderate resistance against the borer. Screening protocols for the eggplant borer are being developed, modified and improved.

i. **Projected outputs:** (1) Sources of resistance or genetic stocks of eggplant with resistance 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 particularly on the mechanism of resistance; (3) Techniques to incorporate borer resistance to commercially grown eggplant varieties.

j. **Projected impacts:** (1) Availability of identified sources of resistance or genetic stocks of eggplant with combined resistance to leafhopper and the eggplant borer; (2) Development of screening techniques in the field and in the mechanism studies; (3) Development of pest resistant eggplant populations with acceptable horticultural qualities.

k. **Projected start:** October 1, 1999

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

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

n. **Budget: PhilRice -** $9,350; Penn State $3,546

I.5 Effect of NPV Against 3rd Instar Larvae of the Common Cutworm, *Spodoptera litura,* Attacking Onions

a. **Scientists:** L.E. Padua, V.P. Gapud – UPLB; M.C. Casimero – PhilRice; N.S. Talekar – AVRDC; E. Rajotte – Penn State

b. **Status:** Continuing activity

c. **Overall Objective:** To determine the efficacy of NPV as biological control agent against *Spodoptera* sp. attacking Yellow Granex. **Year 9 Objective:** Evaluate the efficacy of different commercial formulations of NPV against *S. litura* and *S. exigua* under farmers' field conditions; determine requirements for registration of a local strain (NPV -CRSP).

d. **Hypothesis:** NPV is effective against larvae of *Spodoptera* sp. attacking Yellow Granex at optimum dosages.

e. **Description of research activity:** Commercially available formulations of NPV will be tested in farmers' fields in 5 x 6 m plots for efficacy against *Spodoptera litura*. Monitoring and evaluation of NPV formulations for efficacy against other lepidopterous pests will also be done. The requirements for registration of NPV CRSP will be determined

f. **Justification:** The potential use of NPV-CRSP as a microbial agent has been shown in laboratory conditions. Field tests are needed to determine if the dosages shown to be effective under laboratory conditions are also effective under farmer's field conditions.

g. **Relationship to other CRSP activities at the site:** NPV-CRSP will be a part of the management strategy in the future for controlling *Spodoptera* sp.

h. **Progress to date**: Previous field trials showed that NPV is a potential biological control agent against *S. litura* and *S. exigua*, with efficacy comparable to insecticides. Studies aimed at fine-tuning its formulation, rates, and manner of application showed that the wettable powder, with corn starch or bentonite as carrier, is a promising formulation.

i. **Projected output:** A more concrete picture on the potential of NPV-CRSP against *Spodoptera* sp. will be demonstrated in farmers' fields.

j. **Projected impacts:** (1) Safe alternative to chemical insecticides; (2) Reduced chemical insecticide use.

k. **Projected start:** Delayed until P.L. 480 funds allocated.

l. **Projected completion:**

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

n. **Budget**: 0. This project is delayed until additional funding is available through the P.L. 480 proposal, which has been approved but not allocated. This funding is expected in early 2002.

I.6 Screening Commercial Onion Cultivars for Resistance to Pink Root, *Phoma terrestris*

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

b. **Status:** Continuing activity

c. **Overall Objectives:** (1) To screen local and introduced onion varieties for resistance to pink root; (2) To determine the impact of pink root on yields of onion. **Year 9 Objective:** Confirm pink root resistance or susceptibility and yield of onion varieties screened in Year 8.

d. **Hypotheses:** (1) There are available local and introduced sources of resistance of onion to pink root that can be utilized to manage pink root disease; (2) Selection and development of onion lines with resistance to pink root is the most effective and practical approach in the management of pink root disease.

e. **Description of research activity:** The experiment will be established in a pink -root infested field in Bongabon, Nueva Ecija. Fifteen varieties (local and foreign) that were previously studied in Year 8, except for the most susceptible, will be tested. Another cultivar will be tested in place of the most susceptible one. The cultivars will be planted in raised beds with two rows of per bed in 4 x 5 m plots arranged in RCBD with four replications. All plots will be managed according to farmers' practices and the recommended protocols for weed and insect management will be followed. Ten percent of the total onion plants will be collected at random from each plot and root samples will be assessed for pink root incidence and severity at 25, 50, and 75 DAT. At the end of the season, 2 x 5 m yield cuts will be made at the center of each plot. Bulbs will be classified into small, medium, and large, then weighed.

f. **Justification:** Pink root of onion caused by *Phoma terrestris* is one of the most destructive diseases of onion in Luzon and other onion-growing areas of the Philippine and the world. The pathogen is soil -borne and very difficult to control. Under Philippines conditions, the use of genetic resistance to control the disease is still unexplored. Theoretically, the use of resistant varieties can be a very effective and practical method of managing the disease.

g. **Relationship to other CRSP activities at the site:** This activity will complement the experiments on Biological Control of Soil -borne Diseases.

h. **Progress to date**: The experiment is on its 2nd month and being monitored for pink root incidence. Some varieties have been infected. Resistance and susceptibility will be determined at later stages.

i. **Projected output:** Identification of the most resistant, modera tely resistant, and susceptible locally grown and introduced onion cultivars.

j. **Projected impact:** Reduced pink root infection in the field and increased yields.

k. **Projected start:** October 1, 2000

l. **Projected completion**: September 30, 2002

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

n. **Budget:** PhilRice - $5,335; Ohio State - $4,095

I.7 Insecticide Applications Based on Trends in Sex Pheromone Trap Catches

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

b. **Status**: Continuing activity

c. **Overall Objective**: To develop an efficient monitoring and surveillance system for appropriate timing of interventions against *S. litura* through the use of sex pheromone traps. **Year 9 Objective:** Confirm results obtained in Year 8, with additional treatments.

d. **Hypothesis**: Monitoring and surveillance systems are essential for an effective IPM program. Sex pheromones could be used as a monitoring tool for efficient timing of interventions against *S. litura*.

e. **Description of research activity:** (Treatments subject to change depending on year 2001 results): Sex pheromone baited traps will be installed in the field one month before crop establishment. Catches in sex pheromone traps will be monitored and recorded three times in one week and will be plotted regularly against growth stage of the crop. Trends in trap catches will be the basis for timing of insecticide treatments. There will be five treatments replicated four times in randomized complete block design (RCBD). The treatments are: (1) spray weekly starting at 1 week after transplanting; (2) spray 5 days after a peak in trap catch; (3) spray 7 days after a peak in trap catch; (4) spray 9 days after a peak in trap catch; (5) control (unsprayed). In addition to sex pheromone trap catches, the following information will be recorded: (1) counts of larvae of defoliators and damaged leaves every 2 weeks on 10 randomly selected plants per plot; (2) crop yield.

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

g. **Relationship to other CRSP activities at the site:** This is an important component in the management of *S. litura* in vegetables.

h. **Progress to date:** A 2-year data on sex pheromone trap catches showed that *S. litura* populations start to build up at the start of the onion season and peak after harvest. Trap catches during the rice the season were lower than trap catches during the onion season. An experiment to determine the relationship between trap catches and *S. litura* eggs as monitored in castor plants growing around the onion field showed that peaks in trap catches preceded peaks in egg density. This suggests the possibility of using trend s in trap catches to indicate timing of interventions for efficient control against this pest.

i. **Projected output**: Appropriate timing of insecticide applications against *S. litura* in onion.

j. **Projected impact**: Reduced insecticide misuse in onion.

k. **Projected start:** October 1, 2000

l. **Projected completion**: September 30, 2002

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

n. **Budget:** PhilRice - $1,540; Penn State - $6,492

I.8 Effect of Level of Defoliation at Different Growth Stages on Onion Yields

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

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

c. **Overall Objective:** To determine the relationship between level of leaf damag e and yield loss in onion. **Year 9 Objective:** Determine the level of leaf damage that will cause significant yield loss.

d. **Hypothesis:** Onion can withstand and/or compensate leaf damage caused by leaf feeding insects to a certain level.

e. **Description of research activity:** The experiment will be conducted at the Bongabon Demo Farm and at a farmer's field in Lomboy, Talavera, Nueva Ecija. Artificial defoliation (0, 10, 25, 50 and 75 %) will be done at 15, 30, 45 and 60 days after transplanting (DAT). Artificial defoliation will be done by cutting the leaves off to the desired defoliation level. Plots will be replicated 4 times in RCBD. The following data will be recorded: (1) number of damaged leaves on 10 randomly selected plants at 6 and 7 WAT for leaf miner and at 8 and 10 WAT for *Spodoptera* and *Helicoverpa*; (2) number of larvae of defoliators at 8 WAT; (3) bulb size and weight (10 randomly selected bulbs per plot); (4) sugar content and acidity of bulbs.

f. **Justification:** There is a big information gap on pest damage and yield 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 due to defoliation caused by these pests. Farmers perceive that defoliation, regardless of level, will cause significant yield loss. This perception contributes to the misuse of pesticides in vegetables. A better understanding of pest damage and yield loss relationship is vital for improved pest management decisions.

g. **Relationship to other CRSP activities at the site:** Damage due to defoliation 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 showed that bulb weight was not affected when onion was defoliated by 50% at the vegetative stage (15 and 30 days after transplanting).

i. **Projected output:** Identification of level of defoliation and stage of crop growth that will cause significant yield loss in onion.

j. **Projected impact:** Reduced insecticide application inputs thus lesser health hazards.

k. **Projected start:** October 1, 1999

l. **Projected completion:** September 30, 2002

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

n. **Budget:** PhilRice - $5,390; Penn State - $3,847

II. Laboratory, Greenhouse, and Microplot Experiments

II.1A Biological Control of Soil-Borne Pathogens in Rice-Vegetable Systems

a. **Scientists:** R.T. Alberto – CLSU; M.V. Duca – PhilRice; L.E. Padua – UPLB; R.M. Gapasin – VISCA; S.A. Miller – Ohio State

b. **Status:** Continuing activity

c. **Overall Objectives:** (1) Evaluate selected bacterial and fungal biological control agents for activity against soil-borne pathogens of onion; (2) Develop a bioassay method for evaluation of biocontrol agents; (3) Develop a delivery system of biocontrol agents into onion seedlings. **Year 9 Objective**: (1) Initiate studies to optimize delivery of *Bacillus* sp., *Trichoderma viride*, and *Trichoderma* sp. as biocontrol agents against soil-borne pathogens to onion seedlings under field conditions.

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; (3) Extracts of certain plant species have pesticidal activities against the root-knot nematode.

e. **Description of research activity:** The biocontrol agents *Trichoderma viride, T. harzianum, T. glaucum, T. aureoviride*, and *Trichoderma* sp. (T5), as well as *Bacillus thuringiensis* (LEP 118), will be evaluated further (*in vivo*) for efficacy against *Rhizoctonia solani, Fusarium* spp., and *Sclerotium rolfsii*.

An area naturally infested with soil-borne pathogens will be selected in Bongabon, Nueva Ecija. The selected antagonists will be matched against the pathogens in the soil environment in the presence of onions. Candidate strains will be mixed into sterilized soil at varying concentrations into which soil-borne pathogens (except *P. terrestris*) have been incorporated. Onion will be direct-seeded or transplanted to simulate seedbed conditions. *Bacillus* sp. will be tested by the following methods of delivery: (1) dipping the seedlings into bacterial suspension and planting into fungal pathogen-infested soil in trays in the greenhouse; (2) pouring of bacterial suspension 1 cm away from the base of the plants; and (3) coating of onion seeds with bacterial suspension before seeding. Incidence of damping-off will be evaluated weekly after emergence and final disease evaluation will be made on 60-day old plants by destructive sampling. Promising antagonistic isolates against pink root, damping off and root-knot nematodes will be tested further in 2 x 2.5 m microplots. These microplots will be established in naturally infested fields and the potential biocontrol agents will be introduced, using the three methods of delivery previously described. *Trichoderma* species will be evaluated using the following treatments: (1) *Trichoderma viride;* (2) *Trichoderma* sp. (T5); and (3) fungicide. Seedlings will be dipped in the treatments then transplanted into 4 x 5 m plots replicated four times. The following delivery systems will also be evaluated: (1) broadcasting of biocon agents cultured in appropriate substrate, and (2) combination of seedling dip and broadcasting. Data on percent damping off will be taken at monthly intervals and weight of onion bulbs w ill be recorded at harvest.

f. **Justification:** *Rhizoctonia solani, Fusarium* spp., *S. rolfsii,* and *P. terrestris* are the principal soil -borne fungi causing diseases in onion in the Philippines. Also, the rice root-knot nematode has recently been identifie d as the cause of a serious onion disease. None of these pathogens can be controlled effectively by pesticides or by use of resistant varieties. They are all soil -borne and are good candidates for control using biocontrol agents. The agents selected for this study have shown activity in other systems and have the potential for controlling these pathogens. A bioassay method for soil -borne fungal pathogens is essential for evaluating pathogenicity and the effectiveness of these biocontrol agents. No such bioassay method exists at this time.

g. **Relationship to other CRSP activities at the site:** This study is closely related to the on-going studies on screening for resistance to pink root and cultural management of the root-knot nematode.

h. **Progress to date:** The *Bacillus spp.* LEP 118 reduced the incidence of bulb rot due to three species of *Fusarium* but not *Sclerotium* and *Rhizoctonia*. Dipping of roots in bacterial suspension caused significantly lower bulb rot incidence than soil drenching. *Trichoderma viride* and the *Trichoderma sp.* isolated from onion (T5) showed potential biological control activity against the damping off pathogens of onion in a dual culture technique conducted in the laboratory. In a second trial conducted in the greenhouse *T. viride* and T5 suppressed *Rhizoctonia* and *Sclerotium*.

i. **Projected outputs:** (1) Identification of potential biological control agents against soil-borne pathogens and root-knot nematode; (2) Identification of the most effective method of delivery and optimum conce ntration of the antagonists; (3) Determination of efficacy of plant extracts against the root knot nematode.

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

k. **Projected start**: October 1, 1997

l. **Projected completion**: September 30, 2002

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

n. **Budget:** PhilRice - $3,080; Ohio State - $3,969

II.1B Biological Control of *Meloidogyne graminicola* Using Specific Biological Control Agents and Plant Extracts in Rice-Vegetable Systems

a. **Scientists**: E. B. Gergon – PhilRice; R. M. Gapasin – VISCA; M. Brown, L. E. Padua – UPLB; S. A. Miller – Ohio State

b. **Status**: Continuing research with additional treatments

c. **Overall Objectives:** (1) Evaluate selected biocontrol agents for activity against root knot nematode of onion; (2) Develop system(s) for delivery of biocontrol agents to onion seedlings. **Year 9 Objective:** Evaluate efficacy of selected VAM species, application timings, and combination of VAM and selected organic materials ag ainst the root-knot nematode.

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

e. **Description of research activity:**
Determination of best VAM species. The efficacy of three species of VAM fungi; *Glomus mossae, G. fasciculatum,* and *Gigaspora* sp. *Meloidogyne graminicola* will be tested in pot studies. Seeds of onion cv. Yellow Granex and Red Creole will be sown on sterile substrate inoculated with the different VAM fungi. Nematode-infected roots of 35-40

day old seedlings will be introduced into the soil at 1 day after transplanting. One set -up will be done at BIOTECH and another at PhilRice.

Determination of timing of application. Onion cultivar Yellow Granex or Red Creole will be seeded on sterile substrate inoculated with different VAM fungi. Seedlings from Study No. 1 will be transplanted into infested soil 40 days after seeding. Seedlings grown in sterile soil for 40 days will be immersed in spore suspension or powdered/sheared inoculant one hour before transplanting into infested soil.

Mechanism of suppression of nematodes by VAM. This will be conducted at BIOTECH.

Comparison of VAM fungi, bacterial isolate PSB 9113, and BYM activator for their effectiveness against M. graminicola. Treatments are: (1) seedlings grown on VAM treated soil (best VAM species); (2) seedlings grown on sterile soil and dipped in bacterial suspension; (3 loopfuls/3 ml water) for one hour before transplanting; (3) seedlings grown on sterile soil and dipped in bacterial suspension (3 loopfuls/3 ml water) for one hour before transplanting followed by soil drenching after 1 -2 weeks; (4) BMY activator to be applied based on manufacturer's recommendation; (5) untreated healthy seedlings. All treated and untreated seedlings will be transplanted into 1 x 1x 200 cm microplots filled with soil previously planted to rice infected with *M. graminicola*.

Evaluation of VAM + organic materials (To be conducted at VISCA). Microplots measuring 1 x 2.5m will be infested with *M. graminicola* eggs. Nematode populations will be augmented by planting susceptible rice var UPLRi -5. Rice plants will be harvested 60 days after planting. Initial nematode populations will be determined in each microplot. The following treatments will be used: (1) VAM; (2) VAM + rice straw compost; (3) VAM + chicken manure; (4) VAM + cow manure; (5) VAM + composted sawdust; (6) untreated control. At seedbed, main treatments are with and without rice hull burning; sub-treatments will be 100 spores/5 ml VAM and 50 spores/5 ml VAM; sub-sub-treatments will be broadcast application (on top of the soil) and in -furrow application (seeds placed on top of VAM). In the field, main treatments will be two rates of fertilizer (100% and 50% of recommended rates); sub-treatments will be VAM applied at seedbed and VAM applied as broadcast before transplanting; and sub-sub-treatments will be rates of VAM, 100% and 50% of recommended rate. Treatments will be replicated four times and arranged in RCBD. Data on VAM spore count, VAM infection, number of galls, and population of root -knot in soil and roots will be determined at harvest.

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

g. **Relationship to other CRSP activities at the site:** Results of this experiment will complement 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 than untreated plants.

i. **Projected outputs:** (1) Identification of an alternative method of nematode management in rice-onion system; (2) Additional method of improving seedling establishment in onion; (3) Information on the effect of VAM and reduced fertilizer rates in onion.

j. **Projected impacts:** (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; (3) Reduced fertilizer rates for onion.

k. **Projected start:** October 1, 1999

l. **Projected completion:** September 30, 2002

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

n. **Budget:** PhilRice - $7,590; Ohio State - $2,709

II.2 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. Rajotte – Penn State

b. **Status:** New activity

c. **Overall Objective:** To determine the efficacy of *S. recurvalis* as biological control agent against *T. portulacastrum*. **Year 9 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:** *S. recurvalis*, a natural enemy of *T. portulacastrum* will be collected from onion fields in Bongabon, Nueva Ecija and cultured in the laboratory for biology and life cycle studies. Its feeding behavior on the host plant will be studied. Following the biology and life cycle studies, mass rearing techniques will be developed. Efficacy evaluation studies and host specificity tests will be conducted in preparation for field studies.

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 which are costly, time, and labor consuming. In onion fields at the Bongabon 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**: Not applicable

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, 2001

l. **Project completion:** March 31, 2002

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

n. **Budget:** PhilRice - $7,480; Virginia Tech - $10,216; Penn State - $3,246

II.3 Screening Commercial Onion Cultivars for Resistance to the Anthracnose-Purple Blotch Complex

a. **Scientists:** R. T. Alberto, S. E. Santiago – PhilRice; S. A. Miller – Ohio State; L. Black - AVRDC.

b. **Status:** Continuing activity

c. **Overall Objectives:** (1) Screen local and introduced onion varieties for resistance to anthracnose disease; (2) Determine the impact of anthracnose - purple blotch disease complex on onion yields. **Year 9 Objective:** To confirm resistance of selected onion cultivars evaluated in Year 8.

d. **Hypotheses:** (1) There are available local and introduced sources of resistance of onion to purple blotch which can be used to manage the disease; (2) Use of onion lines with resistance to purple blotch is the most effective and practical approach to the management of purple blotch disease.

e. **Description of research activity:** The experiment will be set up in a field naturally infested with the disease. All varieties planted locally and short day varieties from the U.S. will be tested. The cultivars will be planted in raised beds with two rows per bed in 4 m x 5 m plots. Each cultivar will be replicated six times in a Randomized Complete Block Design (RCBD). All plots will be managed according to farmers' practices and the recommended management approaches for weed and insect problems will be followed. Plots will be evaluated for disease incidence, severity and crop stand at weekly intervals.

At the end of the season, onion yields will be taken from 2m x 3m area at the center of each plot. Bulbs will be classified into small, medium, and large, then weighed. A separate set-up for treated (sprayed) control will be established for yield data.

f. **Justification:** Anthracnose-purple blotch disease complex is one of the most serious diseases of onion in the Philippines and other onion-growing areas of the world. Under Philippine conditions, fungicide sprays are commonly used to manage this disease. Though quite effective, they have a negative impact on environment and health of humans and animals. They also contribute to the development of pathogen resistance to the chemicals. Under current conditions, the use of genetic resistance to control the disease remains unexplored. The use of resistant varieties, therefore, may be the most effective and practical method of management of the anthracnose-purple blotch disease complex.

g. **Relationship to other CRSP activities at the site:** This activity will complement the field screening of onion varieties for resistance to pink root caused by *P. terrestris*.

h. **Progress to date:** The experiment is in its second month and currently monitored for disease incidence and severity.

i. **Projected output:** Identification of resistant varieties of onion.

j. **Projected impact**: Reduced anthracnose-purple blotch incidence and fungicide application.

k. **Projected start:** October 1, 2000

l. **Projected completion**: September 30, 2002

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

n. **Budget:** PhilRice - $2,585; Ohio State - $2,709

II.4 Management of Bacterial Spot of Pepper by Seed Treatment

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

b. **Status**: Continuing activity

c. **Overall Objective:** To develop cost-effective strategies to manage bacterial spot of pepper. **Objectives for Year 9:** (1) Confirm the effects of different rates of commercial sodium hypochlorite, alum, seed treatment fungicides, and hot water alone or in combination with fungicides for control of anthracnose; (2) Evaluate the effects of the same treatments on bacterial spot pathogens of pepper which was not isolated in Year 8; (3) Determine the effects of seed treatment and sprays on the incidence of anthracnose and bacterial spot diseases in the field.

d. **Hypotheses:** (1) Seed treatment is effective in controlling anthracnose and bacterial spot diseases of pepper; (2) Currently available methods and rates of application of seed treatment and sprays are effective against pathogens causing anthracnose and bacterial spot diseases of pepper.

e. **Description of research activity:**

Determination if anthracnose disease is seedborne. Seeds will be collected from infected fruits of bellpepper harvested from a farmer's field. Seeds will be sorted according to degree of discoloration and then sown in the greenhouse.

Effects of different fungicides on the growth of Collectotrichum spp. Fungicides will be used based on manufacturer's rate. 200 ul of each fungicide will be mixed with liquefied potato dextrose agar (PDA). After PDA has solidified, 5 cm-mycelial mat of *Colletotrichum* spp. will be placed at the center of the medium. Fungal growth will be measured after 5 days.

Efficacy of different fungicides, hot water treatment, commercial sodium hypochlorite, and alum as seed treatment against seedborne pathogens of pepper. Infected seeds of pepper will be applied with the above treatments. After treatment, seeds will be air -dried and distributed on plated agar (25 seeds/plate). The number of infected and uninfected seeds will be recorded.

Evaluation of seed treatment and fungicidal sprays for effectiveness against seedborne diseases of pepper. This study will be conducted in the field. Infected seeds of pepper will be applied with different treatments. After treatment, seeds will be air -dried and sown in sterile soil. Seedlings will be transplanted into plots arranged in RCBD with 4 to

5 replications. Monitoring will be conducted at weekly intervals for disease incidence and severity. Yield of pepper will be determined at harvest. Pepper fruits will be sorted by size then weighed.

f. **Justification**: Pepper is becoming an important vegetable in the Philippines. Bacterial spot caused by *Xanthomonas campestris* pv. *vesicatoria* is an important disease of pepper. Anthracnose disease also became serious 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 fungicides have been reported effective as seed treatments and as sprays. However, new chemicals which are less toxic are now commercially available and it would be important to test the efficacy of the new chemicals against these pathogens. The use of sodium hypochlorite, alum, and hot water have also been reported to be effective against seedborne diseases. However, hot water poses a risk of overheating seeds which can affect germination and thus may not be practical to farmers. The use of commercial sodium hypochlorite and alum offers a less toxic and economical solution for control of the disease.

g. **Relationship to other CRSP activities at the site:** This activity should provide information on management tactics 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 *in vitro* have been conducted and promising treatments have been identified.

i. **Projected output:** Identification of approaches to manage bacterial spot and anthracnose diseases of pepper.

j. **Projected impact:** Reduction of seed-borne diseases of pepper with reduced use of fungicides.

k. **Projected start**: October 1, 2000

l. **Projected completion**: September 30, 2002

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

n. **Budget**: PhilRice - $2,530; Ohio State - $2,772

II.5 Retarding Bulb Rot Incidence in Onion With Selected Curing and Storage Methods

a. **Scientists:** D.T. Eligio, Q.D. Dela Cruz – CLSU; R.T. Alberto – CLSU/PhilRice; S.A. Miller – Ohio State

b. **Status:** Continuing activity

c. **Overall Objectives:** (1) Evaluate curing and storage methods in relation to the incidence of bulb rot; (2) Determine the most prevalent rot-causing pathogen in onion storage; (3) Assess the cost effectiveness of curing and storage methods and their combinations. **Year 9 Objective:** To confirm the effects of different curing and storage methods evaluated in Year 8 on bulb rot incidence during onion storage.

d. **Hypotheses**: (1) Curing and providing favorable storage conditions will reduce the incidence of bulb rot; (2) Prolonging the keeping quality of onion bulbs after harvest will increase net returns on investment.

e. **Description of research activity:** One thousand eight hundred kilos of medium-sized Yellow Granex onion will be purchased from an IPM-CRSP cooperator. Three curing methods will be evaluated – sun drying, use of mechanical dryer, and "site-drying". The bulbs for the sun drying and mechanical drying methods will be harvested when the neck had softened and the leaves have toppled down, while the bulbs for "site-drying" method will be harvested when all the leaves have dried up. For the sun drying method, bamboo slats will be used. Freshly harvested bulbs will be arranged closely in rows, the leaves of the adjacent row covering the preceeding row, then sun dried will for 5 to 7 days. Bulbs for the mechanical drying method will be trimmed immediately after harvest prior to sorting. The top portion of the bulbs will be trimmed 2-3 cm from the bulb shoulders and the roots trimmed close to the root plate. The bulbs will be packed in wooden crates with a net weight of 20 kg/crate. Trimming, sorting, and packaging of sun-dried and site-dried bulbs will be the same as above.

For each drying method, bulbs will be kept in two storage conditions: (1) room storage (ambient); (2) cold storage (0^0C, 65-75% RH). There will be 40 crates/lot or 10 crates per treatment combination. The treatment combination per lot will be: (1) storage condition x curing 1; (2) storage condition x curing 2; (3) storage condition x curing 3; and (4) storage condition x control. Factorial experiment in completely randomized design with four replications will be used. Crates of stored onion bulbs will be assessed for percent bulb rotting incidence and weight loss every month for 6 months. Infected bulbs in each crate at each sampling time will be discarded and assessed for the type of rot-causing pathogen to determine the most prevalent and destructive rot -causing pathogen in the storage. All rot -causing pathogens observed will be isolated and tested for pathogenicity. Economic analysis will be done to determine the cost effectiveness of the treatments.

f. **Justification:** Closing of the bulb neck through curing ha s been known to reduce or delay the onset of bulb rot in onion. However, only 14 percent of onion growers cure their onions before storage (Calica et al., 1998). This results in huge losses of onions after harvest. The situation is aggravated by the infr equent use of cold storage, which could arrest the activity of the rot-causing pathogens. Calica at al. (1998) reported that only 13 percent of farmers store their onions in cold rooms. Susceptibility of bulb onion to rotting is a nightmare to growers t hat forces them to sell their crops immediately after harvest when supplies are high and prices are relatively low. If farmers could maintain the keeping quality of their produce after harvest, they could sell when prices are high thus obtain higher net returns on their investment.

g. **Relationship to other CRSP activities at the site**: This activity will complement the biological control studies against soil -borne pathogens to reduce the incidence of bulb rot in the field.

h. **Progress to date**: This is a relatively new study.

i. **Projected outputs:** (1) Identification of best and most cost-effective curing and storage methods that will reduce the incidence of bulb rot; (2) Identification of the most prevalent rot-causing pathogens during storage.

j. **Projected impact:** (1) Reduction of bulb rot in storage; (2) Higher net returns

k. **Projected start:** October 1, 2000

l. **Projected completion:** September 30, 2002

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

n. **Budget:** PhilRice - $2,585; Ohio State - $3,402

III. Socio-Economic Impact Analysis Studies

III.1 Social Impact Assessment of IPM CRSP Technologies

a. **Scientists:** R.B. Malasa I. R. Tanzo, Nicos Perez – PhilRice; C. Harris - Virginia Tech; C. Sachs - Penn State

b. **Status:** Continuing activi ty

c. **Overall Objectives**: (1) To determine the communities' perception on the use/adoption of an IPM CRSP technology; (2) To identify and assess the possible social effects and impacts of IPM CRSP technologies on the community; (3) To identify and suggest possible mitigation and enhancement measures of the impacts of IPM CRSP technologies. **Year 9 Objective:** To conduct social impact assessment studies on rice hull burning and selected weed management strategies.

d. **Hypothesis:** IPM CRSP technologies will be beneficial 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. Informal group interviews will also be conducted. An assessment will be made of the anticipated social environment, with and wit hout 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 will may be affected, and (4) how long these effects are likely to last. Sug gestions will be made for mitigating negative impacts of the technologies or increasing positive impacts.

During year 7 a follow-up survey to the original baseline survey was carried out with both male and female farmers. The data produced by this survey will be analyzed by the end of project year 8. During year 9, additional analysis will take place to provide a report on the social impact and implications of the IPM technologies used by the survey's respondents. This information will be used to plan an intervention for year 10 related to community participation in IPM, and to try fill any gaps and ameliorate negative impacts of the IPM technology and enhance positive ones.

f. **Justification**: The impact of a 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. **Relation to other CRSP activities at the site:** This study will complement the economic and environmental impact assessment studies.

h. **Progress to date:** Analysis of the follow-up survey completed in Year 7 will be finished in Year 8.

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

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

k. **Projected start:** October 1996

l. **Projected completion:** November 2003

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

n. **Budget:** PhilRice – $8,030; Va Tech - $3,193; Penn State - $24,525

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 impacts 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 9 Objective:** To conduct economic impact assessment studies on stale-seedbed techniques (weed management) and other promising technologies developed in Year 8.

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

e. **Description of research activity**: (1) Budgets will be developed for current crop practices and for each of the alternative pest management practices being evaluated in field experiments. Changes in the cropping system will be assessed in determining changes in farm-household income with and without specific IPM practices being tested. 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. (2) For the biotech assessment, economic surplus analysis will be conducted using an economic model to account for spillovers of benefits across countries. Data on production and prices of rice and eggplant in major countries in the region will be combined with information on likely yield and cost effects from experimental data, and with projections on adoption across countries and by farm size. These data will be included in the ES model to generate estimates of economic benefits. The technologies will focus on Bt rice and eggplant and rice modified for bacterial leaf blight resistance. The bio technologies are those being developed at IRRI and PhilRice for rice and in India for eggplant. Environmental benefits will be assessed for the Philippines by projecting reductions in pesticide a.i. per hectare, and simulating the economic value to the environment using values generated for the Philippines by Cuyno.

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 the IPM practices. Projecting benefits of biotech technologies is important in deciding which technologies should be pursued in research and in providing the general public with accurate information on the impacts of the technologies.

g. **Relation 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 in January 2001. It indicates which of the developed technologies have a yield enhancing and cost reducing effect over the current farmer's practice. A MS thesis looking at the effects of rice biotechnologies is well underway and will be completed early in year 9.

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

j. **Projected impacts:** The results should influence decisions on which technologies to promote in training programs, on which IPM alternatives might justify further research, and on pest management policies and regulations. They also may better inform the general public on the benefits and costs of biotechnologies.

k. **Projected start:** October 1, 1995

l. **Projected completion:** September 30, 2002

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

n. **Budget:** PhilRice - $880; Virginia Tech - $8,885

III.3 IPM Technology Transfer and Feedback

a. **Scientists:** IPM CRSP and Training Staff of Technology Transfer Division – PhilRice; L.E. Padua, M. C. Lit, N. L. Opina, A.M. Baltazar – UPLB; E. Rajotte – Penn State; S.A. Miller – Ohio State; G. 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 9 Objectives:** (1) Develop a training course on vegetable IPM, publish training modules and other IPM training materials in collaboration with and for implementation by training staff of the Technology Transfer Division (TTD) of PhilRice; (2) Conduct village level integration and techno-demo studies in farmers' fields.

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

e. **Description of activity:** The following activities to transfer technology and disseminate information on IPM in rice-vegetable systems will be done: (1) IPM CRSP scientists will act as trainers or resource persons in training courses conducted by the PhilRice Training and Extension Division or other government agencies (i.e. DA-ATI) and universities; (2) Village level integration projects using on-farm demo plots in collaboration with PhilRice Rice-Based Farming Systems Division; (3) Production of training materials; (4) Publication and presentation of research results in scientific journals and in conferences. Training modules, brochures, manuals, fact sheets and similar materials will be published in collaboration with PhilRice Extension and Training Division. Short-term and season–long training courses will be conducted at two levels: (1) training of trainers (provincial level); (2) training of municipal extension workers by trainees of the first level. Field days and farmer meetings will be conducted during the onion season at the IPM CRSP experimental sites.

f. **Justification:** This activity will ensure the spread of results of IPM CRSP research to farmers and provide feedback to project scientists. It will increase awareness among farmers about the project and the need to practice IPM in vegetables.

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 6 to 7 years of the project. It will also complete the IPM training process for rainfed lowland rice farmers that began in rice. It will reinforce PhilRice's role in the national IPM training of farmers in rice -vegetable systems.

h. **Progress to date:** (**1) Training courses**: Short-term and season-long trainingcourses on: (a) IPM in onion and eggplant; (b) IPM in rice -vegetable systems; and (c) mass production of NPV were conducted at PhilRice from July 1999 to date in collaboration with the PhilRice Training and Extension Division. IPM CRSP scientists also acted as resource persons in several training courses conducted by PhilRice and two agricultural universities; (**2) Village level integration project**: On-farm demo plots comparing IPM CRSP technologies and farmer's practice were established in 6 farmers fields (3 in San Jose and 3 in Bongabon, Nueva Ecija) during the 2001 onion cropping season (January to April); (**3) Training materials**: Fact sheets, brochures, and a training module on IPM in Rice-Vegetable Systems have been written and are being edited in preparation for publication by PhilRice Training and Extension Division; (**4) Publications and paper presentations**: More than 10 research papers were presented by IPM CRSP scientists at local and international conferences and a similar number were published in Philippine and international journals.

i. **Projected outputs:** (1) IPM training materials for onion and eggplant; (2) A season -long vegetable IPM training curr iculum/module developed and tested; (3) Technical papers and popular articles on IPM.

j. **Projected impacts:** (1) Increased awareness of vegetable IPM in Nueva Ecija; (2) Increased application of IPM principles and practices; (3) Reduced pesticide use and increased vegetable production, particularly onion and eggplant.

k. **Projected start**: October 1, 1999

l. **Projected completion**: September 30, 2002

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

n. **Budget**: PhilRice Funds

INTEGRATED PEST MANAGEMENT – COLLABORATIVE RESEARCH SUPPORT PROGRAM (IPM CRSP), SOUTHEAST ASIA SITE IN THE PHILIPPINES
(September 30, 2001 – September 29, 2002)

ACTIVITY	SCIENTISTS	BUDGET ($)
FIELD EXPERIMENTS (On-Farm and PhilRice CES)		
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.	PhilRice 5,830 Va Tech 3,193
I.2 Seasonal Abundance and Economic Importance of *Liriomyza* sp. in Rice-Onion Cropping System	G.S. Arida, E.R. Tiongco, B.S. Punzal, C.C. Ravina – PhilRice; E. Rajotte - Penn State U	PhilRice 5,390 Penn State 2,164
I.3 Influence of Host Plant Resistance and Grafting on the Incidence of Bacterial Wilt of Eggplant	N.L. Opina – UPLB, R.T. Alberto, S.E. Santiago – PhilRice and S.A. Miller – Ohio State	PhilRice 8,085 Ohio State 2,709
I.4 Combined Resistance of Eggplant, *Solanum melongena* L., to 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. Rajotte – Penn State	PhilRice 9,350 Penn State 3,546
I.5 Effect of NPV-CRSP Formulation Against 3rd Instar Larvae of the Common Cutworm, *Spodoptera litura* Attacking Onions	L.E. Padua, V.P. Gapud – UPLB, M.C. Casimero – PhilRice, N.S. Talekar – AVRDC, Taiwan, E. Rajotte – Penn State Univ.	PhilRice (delayed) Penn State (delayed)
I.6 Screening Commercial Onion Cultivars for Resistance to	R.T. Alberto, M.V. Duca – PhilRice; S.A. Miller – Ohio State	PhilRice 5,335 Ohio State 4,095

Pink Root *Phoma terrestris*		
I.7 Insecticide Applications Based on Trends in Sex Pheromone Trap Catches	G.S. Arida, B.S. Punzal, C.C. Ravi na, – PhilRice; N.S. Talekar – AVRDC; and E. Rajotte – Penn State U	PhilRice 1,540 Penn State 6,492
I.8 Effect of Level of Defoliation at Different Crop Ages on Onion Yields.	G.S. Arida, C.C. Ravina, B.S. Punzal – PhilRice; E. Rajotte – Penn State	PhilRice 5,390 Penn State 3,847
LABORATORY, GREENHOUSE, AND MICROPLOT EXPERIMENTS		
II.1A Biological Control of Soil-Borne Pathogens in Rice-Vegetable Systems	R.T. Alberto, E.B. Gergon, M.V. Duca – PhilRice; L.E. Padua – UPLB (Biotech); R.M. Gapasin – ViSCA; S.A. Miller – Ohio State	PhilRice 3,080 Ohio State 3,969
II.1B. Biological Control of *Meloidogyne graminicola* Using Specific Biological Control Agents and Plant Extracts in Rice-Vegetable Systems	R. T. Alberto, E.B. Gergon– PhilRice; R. Gapasin – VISCA; M. Brown – UPLB; L. E. Padua – UPLB; Sally Miller – Ohio State	PhilRice 7,590 Ohio State 2,709
II.2 Biology, Life Cycle and Mass Rearing of *Spoladea recurvalis*	A.M. Baltazar – UPLB; E.C. Martin, M.C. Casimero, J.M. Ramos – PhilRice; S.K. De Datta, Loke T. Kok – Virginia Tech; E.Rajotte – Penn State	PhilRice 7,480 Va Tech 10,216 Penn State 3,246
II.3 Screening Commercial Onion Cultivars for Resistance to the Anthracnose- Purple Blotch Complex	R.T. Alberto, S.E. Santiago – PhilRice; S.A. Miller – Ohio State U; L. Black - AVRDC.	PhilRice 2,585 Ohio State 2,709
II.4 Management of Bacterial Spot of Pepper by Seed Treatment	E. Gergon– PhilRice; N. Opina - UPLB; Sally Miller – Ohio State.	PhilRice 2,530 Ohio State 2,772

II.5 Curing and Storage in Retarding Bulb Rot Incidence in Onion	D.T. Eligio, Q.D. Dela Cruz – CLSU, R.T. Alberto – CLSU/PhilRice, S.A. Miller – Ohio State	PhilRice 2,585 Ohio State 3,402
SOCIO-ECONOMIC ANALYSIS		
III.1 Social Impact Assessment of IPM CRSP Technologies	R. B. Malasa, S. R. Francisco, I. R. Tanzo – PhilRice; C. Harris, G. Norton - Virginia Tech	PhilRice 8,030 Va Tech 3,193 Penn State 24,525
III.2 Economic Impacts of IPM Practices in the Rice-Vegetable Systems	S. Francisco – PhilRice; G. Norton – Virginia Tech	PhilRice 880 Va Tech 8,885
III.3 IPM Technology Transfer and Feedback.	IPM CRSP Staff, L.E. Padua, M.C. Lit, N.L. Opina – UPLB; Training staff of Technology Transfer Division – PhilRice; E. Rajotte – Penn State U; S.A. Miller – Ohio State; G. Norton – Virginia Tech	PhilRice-funded

Ninth Year Work plan for the South Asian Site in Bangladesh

In year 9, the IPM CRSP will begin its fourth year of research in Bangladesh. Activities focus on rice/vegetable systems, with key crops including eggplant, cabbage, gourds, tomatoes, 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 testin g 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, 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 activitie s 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 Insti tute (BRRI), CARE-Bangladesh, and with the agricultural university at Mymensingh and the Institute for Post Graduate Studies in Agriculture (IPSA) near BARI for student training. International and U.S. institutions contributing to the IPM CRSP program in B angladesh include AVRDC, IRRI, the National Crop Protection Center of the Philippines, Penn State, Ohio State, and Virginia Tech.

IPM CRSP research activities in Bangladesh will be carried out in year nine under four major thematic areas: (a) crop/pest monitoring, (b) multidisciplinary on -farm pest management experiments, (c) multidisciplinary laboratory, greenhouse, and microplot experiments, and (d) socioeconomic analyses.

I. Baseline Survey and Crop/Pest Monitoring

I.1 Monitoring of Pests and their Natural Enemies in Vegetables in Rice – Vegetable Systems

a. Scientists: Z. Islam – BRRI; S.N. Alam, M.F. Zaman, M. Khorsheduzzaman, M.A. Rahman, M.I. Faruque, Anwar Karim, S.A. Khan – BARI; M.S. Alam, A. Bashet – IPM CRSP; L. Black – AVRDC; E. Rajotte – Penn State; A. Baltazar – NCPC/UPLB; S.K. De Datta, G. Luther – Virginia Tech

b. Status: Continuing

c. Objectives (overall and current year): (1)To determine the incidence and seasonality of, damage due to, and management of major vegetable pests (insec ts, diseases, nematodes and weeds) in major vegetable growing areas; and (2) To identify appropriate researchable issues for developing IPM practices in vegetables.

d. **Hypotheses:** (1) Pest and natural enemy population fluctuations affect crop production i n rice-vegetable systems; and (2) Cropping patterns influence incidence and abundance of pests and natural enemies.

e. **Description of research activity:** Pest surveys on rice crops will be discontinued in order to carry out fairly extensive pest surveys of vegetable pests in major vegetable growing areas of Comilla, Narsingdi, Jessore, Sripur and some selected areas during both the winter and summer seasons. Incidence of insects, diseases, nematodes, generalist predators and weeds will be determined bi -weekly intervals by visually recording pest incidence (species), assessing pest intensity and damage level by direct count (hill/head, fruit/quadrat) and by visual scoring. Parasite incidence will be identified by rearing of immatures. Weed incidence and density will be determined by using a 1m x 1m quadrat, and weed biomass will be recorded by weighing the fresh and dry weights of the prevailing species. Adopted cultural pest management practices will be recorded through farmer interviews. Several fields in each site will be surveyed.

f. **Justification:** The pest and natural enemy complex in rice -vegetable systems is poorly understood. It is important to understand the seasonal fluctuations of pests and natural enemies and their association as it will lead to the i dentification of research issues and priorities for solving pest problems in rice -vegetable systems.

g. **Relationship to other research activities at the site:** The surveys will help other research groups to identify appropriate researchable issues for the development of IPM technologies.

h. **Progress to date:** Monitoring of rice pests and natural enemies has been done during the T. Aman rice season (dry season). Several major vegetable pests have been identified in the Kashimpur area in previous years. Furth er monitoring of vegetable pests is going on.

i. **Projected outputs:** Improved knowledge of (1) key pests and improved understanding of the role of existing natural enemies in pest management; (2) the extent of losses induced by major pests, and 3) research able issues.

j. **Projected impacts:** (1) Identified appropriate research activities; (2) Better understanding of pest situation in rice -vegetable systems.

k. **Projected start:** October 1998

l. **Projected completion:** September 2002

m. **Projected person-months of scientists time per year:** 10 person-months

n. **Budget:** US$ 3850: BARI/BRRI; $10,160: Penn State; $6100: NCPC/UPLB

II. Multidisciplinary On-farm Pest Management Experiments

II.1a 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

a. Scientists: M.A. Rashid, M.M. Hossain, M.A. Rahman, Motiar Rahman, S.N. Alam, M.H. Rashid, M.I. Faruk – BARI; H.S. Jasmine, M. S. Alam, A. Bashet – IPM CRSP; L. Black, J.F. Wang, N.S. Talekar – AVRDC; G. Luther – Virginia Tech

b. Status: Continuing

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 2001-2002:** (1) To confirm the resistance of the eggplant varieties selected in 2000-2001 against FSB, BW and RKN; and (2) To test new tomato germplasm against BW, RKN and TYLCV, and confirm the resistance of the varieties selected in 2000-2001.

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 2001-2002. Approximately 100 cultivars of eggplant and 50 cultivars/lines as well as tolerant lines of tomato which 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 2-5 and 2-3 for eggplant and tomato, respectively, the resistant varieties evaluated 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 March 2002 and transplanted in April 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 1st 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 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 2000-2001 winter season, 120 germplasm lines of eggplant have been evaluated against bacterial wilt and RKN in sick -beds, and 55 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 39 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 resistanc e 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: 2004

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

n. Budget: US$ 5500: BARI; $8768: Ohio State

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, Ataur Rahaman, A.K.M. Quamaruzzaman – BARI; M. Rafiquddin – RARS, BARI (Jessore); H.S. Jasmine, M.S. Alam, A. Bashet – IPM CRSP; G. Luther – Virginia Tech; L. Black – AVRDC

b. Status: New

c. Objectives: 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 20 01. 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 wil l 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 2001.

f. **Justification:** Bacterial wilt *(Ralstonia solanacearum*) is a devastating disease of eggplant in Ban gladesh 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 farmers' 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:** Demonstration trial at Kashimpur and on -station experiment at BARI farm in 2001 winter season showed that grafting was highly successful in controlling BW disease, establishing very high plant populations, producing high yield and bringing about high economic returns.

i. **Projected output(s):** Utilization of grafting by the farmers will help in obtaining a better crop stand, higher yields and greater economic ret urns.

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 2002

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

n. **Budget:** US$ 3520: BARI; $1705: Ohio State

lI.1c Development of Eggplant Hybrids Resistant to Bacterial Wilt, FSB and RKN

a. **Scientists:** M.A. Rashid, Motiar Rahman, A.K.M. Quamaruzzaman, M.M. Hossain, M. Nazimuddin – BARI; M.S. Alam, A. Bashet – IPM CRSP; G. Luther – Virginia Tech; L. Black, J.F. Wang – AVRDC

b. **Status:** Continuing

c. **Objectives:** To develop high yielding/hybrid varieties of eggplant resistant to bacterial wilt and FSB through hybridization. **Objectives in 2001-2002:** (1) To confirm the performance of the four promising hybrids selected in 2000 -2001; and (2) To include in the breeding program 13 new parents identified to resistant to the pests and test their performance.

d. **Hypotheses:** Bacterial wilt 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:** The experiment is presently being carried out at BARI farm. Performances of several hybrids and inbreds appear to be promising.

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 2004

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

n. **Budget:** US$ 2860: BARI; $4705: Ohio State

II.1d Screening of pumpkin germplasm against Watermelon Mosaic 2 Poty Virus (WMV2).

a. **Scientists:** M.A. Rashid, M.A.T. Masud, M.H. Rashid – BARI; M.A. Mannan Akand – BSMRAU; H.S. Jasmine, M.S. Alam – IPM CRSP; G. Luther – Virginia Tech; L. Black, J.F. Wang – AVRDC

b. **Status:** New

c. **Objectives:** To (1) locate sources of WMV2 resistance in pumpkin germplasm; (2) identify agronomically acceptable resistant line(s) for varietal release; and (3) use resistant sources in a variety improvement program, (4) study the epidemiology of the vectors (e.g., aphids) of the virus. **Objectives in 2001-2002**: To identify the sources of WMV2 resistance in local and exotic germplasms through field test and artificial inoculation method.

d. **Hypotheses:** WMV2 of pumpkin is a serious disease in Bangladesh and pesticide use f or 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 germpla sm 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 ?-carotene).

e. **Description of research activity:**

Plant materials : Fifty pumpkin germplasm lines, collected from local and exotic sources and preliminarily identified resistant sources, will be artificially inoculated to study their reactions against WMV2 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 (WMV2). 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: (1) Highly resistant (HR): No infection – 0; (2) Resistant (R): Up to 1 % leaf area infection – 1; (3) Moderately resistant (MR): > 1 to 5 % leaf area infection – 2; (4) Moderately susceptible (MS): > 5 to 25 % leaf area infection – 3; (5)

Susceptible (S): > 25 to 50 % leaf area infection – 4; (6) 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 improved 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:** New

i. **Projected outputs:** (1) Identification of WMV2 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 WMV2-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.

k. **Projected start:** October 2001

l. **Projected completion:** September 2004

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

n. **Budget:** US$ 2860: BARI; Ohio State

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; M.S. Alam, A. Bashet – IPM CRSP; N.S. Talekar – AVRDC; E. Rajotte – Penn State; G. Luther – Virginia Tech

b. **Status:** Continuing

c. **Objectives:** To minimize the infestation of lepidopteran pests on cabbage using an integrated control approach and produce healthy cabbage crops.

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 pes ts 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 larvae, 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 Kashimpur. 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 apply insecticides at high frequency 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 infestation was 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 incomes. 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 2002

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

n. **Budget:** US$ 3630: BARI; $1270: Virginia Tech

II.2b Management of Cabbage Pests Using a Nylon Net Physical Barrier

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

b. **Status:** Continuing

c. **Objectives:** To minimize the infestation of various insect pests on cabbage and produce healthy cabbage free from toxic residues of pesticides.

d. **Hypothesis:** Nylon nets covering the sides and the top of the cabbage plots will reduce attack of *Spodoptera litura*, diamondback moth *(Plutella xylostella), Crocidolomia binotalis,* and other pests.

e. **Description of research activity:** There will be three treatments with four replications in RCB design, conducted at the BARI experiment station. The treatments are: (1) Net barrier 2m high surrounding the plot and also covered on the top; (2) Insecticidal applications at 15-day intervals; (3) Control (no net barrier). There will be no pesticides used and no handpicking of pests from the cabbage plants. Plot size will be 7 x 6m, and nets will be white in color. Nets will be set up before transplanting cabbage. Cabbage seedlings will be transplanted in peat in October -November. Seedlings must be pest-free. Numbers of lepidopteran larvae and pupae, and any other major pests, will be monitored and recorded once per week in cabbage. Data will be recorded on predators and parasitoids. Head weight, size, and compactness will be recorded from all plots.

f. **Justification:** Lepidopteran leaf feeders are serious pests of cabbage in Bangladesh. There has been notable success in reducing lepidopteran pest numbers with nylon net barrier in other Asian countries.

g. **Relationship to other research activities at the site:** This will be a part of the crucifer 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 during 1999-2000 and 2000-2001. In the first year, insect infestation was too low to understand the effect of the barrier method. In the second year, pest infestation was moderate and plots having net barrier had lowest infestation and gave better yields.

i. **Projected outputs:** Improved knowledge on integrated pest management in cabbage to control lepidopteran leaf feeders.

j. **Projected impacts:** Use of nets will enable a substantial reduction of pesticide use, which will have a positive impact on the environment and human health.

k. **Projected start:** October 1999

l. **Projected completion:** April 2003

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

n. **Budget:** US$ 2420: BARI; $6985: Penn State:$1270: Virginia Tech; $1705: Ohio State

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

a. **Scientists:** S.M. Monowar Hossain, Amir Hossain, Salim Reza Mollik, M. Nazimuddin, M. Khorsheduzzaman, K.A. Kader – BARI; M.S. Alam, A. Bashet – IPM CRSP; 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. **Objective in 2001-2002:** To identify the growth stage(s) of okra plants which is critical for vector (white fly) infestation and YMV transmission.

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 taken off 7 days after emergence of plants
C_2	Net barrier taken off 14 days after emergence of plants
C_3	Net barrier taken off 21 days emergence of plants
C_4	Net barrier taken off 28 days after emergence of plants
C_5	Net barrier taken off 35 days after emergence of plants
C_6	Net barrier taken off 42 days after emergence of plants

C7 Net barrier from planting to harvest

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 1st 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 trial is being carried out during 2001 summer season. Data are not yet available.

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 2003

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

n. **Budget:** US$ 2510: BARI; $5750: Penn State; $1270: Virginia Tech

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

a. Scientists: S.M. Monowar Hossain, Salim Reza Mollik, Amir Hossain, M. Nazimuddin, M. Khorsheduzzaman – BARI; M.S. Alam, A. Bashet – IPM-CRSP; E. Rajotte – Penn State; G. Luther – Virginia Tech.; L. Black – AVRDC.

b. Status: New

c. Objectives: To: (1) produce vegetables and increase their availability during the off-season and (2) produce pesticide-free vegetables. **Objective in 2001-2002:** 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).
<u>Crops under sequential cropping system:</u> Summer Cabbage (March-May); Summer tomato (June-Sept) – Okra (Oct-Feb).
<u>Varieties</u>: Tomato- BARI tomato- 5/ Anupuma; Okra-BARI Dherosh-1; Cabbage- KK cross.
<u>Treatments</u>: T1- Net on all sides + polythene top; T2- Polythene top only; and T3- Control (without net or polythene barrier).
<u>Data to be recorded:</u> 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: New

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 2003

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

n. **Budget:** US$ 3,080: BARI.

II.3 Determination of Cucurbit Fruit Fly (*Bactrocera cucurbitae*) Incidence Pattern and its Management in Sweet Gourd, Bitter Gourd and Cucumber Using Male and Female Sex Attractants

a. **Scientists:** M. Nasiruddin, S.N Alam, M.F. Zaman, M. Khorsheduzzaman – BARI; H.S. Jasmine, M.S. Alam – IPM CRSP; E. Rajotte – Penn. State; G. Luther – Virginia Tech; N.S. Talekar – AVRDC

b. **Status:** Continuing

c. **Objectives:** To (1) determine the yearly population fluctuation pattern of fruit flies and the relationship between trap-captured fruit flies and fruit infestation; (2) compare the effectiveness of male and female sex attractants as a fruit fly trapping technique; and (3) assess sex-attractant traps as an environmentally-friendly and cost-effective approach to fruit fly management.

d. **Hypothesis:** (1) Male and female sex attractants can be used to monitor the incidence pattern of cucurbit fruit flies and it will help formulate control strategies; and (2) Evaluation of the sex attractants will lead to the use of the most effective agents for fruit fly management

e. **Description of research activity:** Three different experiments will be set up to achieve the objectives of the study: (1) yearly incidence pattern of the fruit fly in farmer fields at Kashimpur; (2) comparison of the effectiveness of male and female sex attractants at BARI farm and (3) management of the fruit flies by using sex attractant traps in farmer fields in Kashim pur.
Determination of yearly incidence pattern of fruit fly: Bait traps of different sex attractants will be established throughout the year in three locations of Kashimpur in farmer fields. In each location, three traps (3 replications in RCB) of each of the three attractants will be placed in the same plot to capture the fruit flies. The attractants will

consist of: (1) male attracting pheromone-cuelure, (2) female attracting pheromone-FFA, FFT & FFP, and (3) male and female attracting mashed sweet gourd bait-MSG. Replacement of the trapping material will be done when necessary. Weekly observations on fruit fly capture, and the number of infested and healthy fruits will be recorded. Records will also be maintained on the prevailing temperature and humidity and cucurbit crops cultivated in the area.

Comparison of the effectiveness of some sex pheromone dispensers and MSG: The experiment will be carried out at BARI farm. The experiment will be established in a 29m X 29m field laid out in RCB design with three replications having a plot size of 9.5m X 2.5m. Each plot will contain 4 cucurbit plants grown in pits. There will be 9 treatments: T1- Cuelure (male attractant); T2- FFA (female attractant); T3- FFT (female attractant); T4- FFP (female attractant); T5- Combination of FFA, FFT, & FFP; T6- Combination of FFA & FFT; T7- Combination of FFA & FFP; T8- Combination of FFT & FFP; and T9- MSG (male & female attractant). Each plot will receive one treatment. Data will be recorded weekly on male and female fruit flies.

Management of cucurbit fruit fly with male sex attractant (cuelure) and MSG: The experiment will be conducted in three locations of Kashimpur area in farmer fields. There will be three treatments laid out in three replications: T1 - Mashed sweet gourd trap; T2- Cuelure (male sex pheromone); and T3 - Control. Data will be recorded weekly on the number of male and female flies caught, healthy (uninfested) fruits, partially infested but marketable fruits, and fully infested and non-marketable fruits. Economic analysis will also be done.

f. **Justification:** Tracking the presence of male and female fruit flies by using the sex attractants throughout the year will help to understand the relationship between fruit fly capture and fruit injury level and thus will help to establish a recommendation for effective control technique e.g. time of planting, mass trapping or selective application of pesticide. Comparative evaluation of different types of male and female sex pheromones will lead to the identification of effective attractants for their use in fruit fly control. Cuelure and MSG, found to be effective as fruit fly attractants, can be utilized in fruit fly management which will reduce indiscriminate use of pesticides.

g. **Relationship to other CRSP activities at the site:** Findings of this study can be applied to other cucurbit crops grown in the country and can also be combined with other IPM packages.

h. **Progress to date**: Results of the previous years showed that between the two male attracting test pheromones, cuelure was the best in attracting the cucurbit fruit flies. On the other hand, MSG attracted both male and female fruit flies. Both the sex attractants reduced the fruit fly populations as well as fruit injury and raised the yields of the cucurbit crops.

i. **Projected outputs:** (1) Better understanding of fruit fly population fluctuation and adoption of timely control measures; (2) Establishment of pesticide free control measures, higher yields of cucurbit fruits and greater economic benefits.

j. **Impacts:** Integrated management of cucurbit fruit fly will help to establish a cost effective, environmentally safer crop protection strategy in cucurbit fields.

k. **Projected Start:** October 2000

l. **Projected completion:** September 2002

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

n. **Budget by institution:** US$ 2750: BARI; $1100: AVRDC

II.4 Crop Loss Due to Weed Infestation and Efficacy of Different Weed Control Methods

a. **Scientists:** Anwar Karim, S.A. Khan – BARI; A.N.M.R. Karim, M.S. Alam, A. Bashet – IPM CRSP; A. Baltazar – NCPC/UPLB; S.K. De Datta – Virginia Tech

b. **Status:** Continuing

c. **Objectives:** To determine the optimum number of weedings in eggplant and tomato. **Objectives in 2001-2002:** (1) To confirm the results of the promising weeding tre atments identified in 2000 -2001 trials of eggplant; and (2) To test the same weeding treatments in tomato crop, which was included in previous trials.

d. **Hypotheses:** (1) Weeds growing with eggplant and tomato reduce yield; and (2) Weed control operations completed at critical stages of crop growth will improve weed control and increase yield.

e. **Description of research activity:** The efficacy of weeding at different growth stages will be evaluated in two farmer fields for each crop in 4m X 5m plots repli cated four times in an RCB design. The treatments for eggplant crop will consist of: T_1 - one hand weeding (HW) at 21 DAT (days after transplanting); T_2 - two HW at 21 and 42 DAT; T_3 - weed free (continuous weeding); T_4 - mechanical weeding by BARI weedier at 21 DAT and IHW at 42 DAT; T_5 - farmer practice (time and frequency of weeding to be recorded); T_6 - straw mulch; and T_7 - control (no weeding). The treatments for the tomato crop, on the other hand, will be: T_1- one hand weeding at 21 DAT (early veget ative stage); T_2 - two hand weeding at 21 DAT and 35 DAT (flowering stage); T_3 - two hand weeding at 21 DAT and 49 DAT (marvel size fruiting stage); T_4 - three hand weeding at 21 DAT, 35 DAT and 49 DAT; T_5 - weed free (continuous weeding; T_6 - farmer pract ice; and T_7 - control (no weeding). Data will be recorded on (1) fresh and dry weight of weeds by species at 21, 35, 42, & 49 DAT and 2 weeks before harvest, (2) crop yield and other yield components, (3) number of days to crop maturity, and (4) time spen t for hand weeding (min/plot or hour/crop).

f. **Justification:** Crop loss in farmer fields due to weed infestation is a common phenomenon. Farmers use long period of time and labor in controlling weeds. There is a need to develop a cost-effective weeding scheme to reduce yield loss and also reduce production cost due to weed control.

g. **Relationship to other research activities at the site:** This activity will make use of data gathered in weed monitoring.

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.

i. **Projected outputs:** Cost effective weeding scheme will be available to vegetable growing farmers.

j. **Projected impacts: Reduced:** Reduced production cost and increased profit.

k. **Projected start:** October 2001 (continuation for eggplant and new for tomato)

l. **Projected completion :** September 2002 (only the trials in tomato will be continued in 2003)

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

n. **Budget:** US$ 2640: BARI; $6100: NCPC; $2540: Virginia Tech

II.5a Integrated Management of Soil-Borne Pathogens of (a) Eggplant in the Farmer Field in Jessore and Jamalpur, and (b) Cucumber and Tomato at Kashimpur

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

b. **Status:** Continuing

c. **Objectives**: To (1) confirm the previous results of the use of sawdust burning, poultry refuse and mustad oil-cake obtained at Kashimpur; (2) demonstrate the efficacy of sawdust burning in nursery beds; and poultry refuse and mustard oil -cake in the main field of eggplant for the control of soil-borne pathogens and increased yield; and (3) assess the effectiveness of soil amendments in controlling fungal and nematode diseases of cucumber and tomato at Kashimpur. **Objectives in 2001-2002:** (1) To confirm the results as well as to demonstrate the usefulness of soil amendment practices with sawdust, poultry refuse and mustard oil-cake in eggplant crop in farmer fields of

Jamalpur and Jessore districts (intensive eggplant growing areas); and (2) To determine the effects of soil amendment treatments at Kashimpur site in tomato crop which was included in previous trials.

d. **Hypothesis**: Soil amendments reduce the populations of soil-borne pathogens of eggplant, cucumber and tomato, and help establish satisfactory crop stand to produce higher yields.

e. **Description of research activity**: (1) 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 field of eggplant will be conducted at Jessore and Jamalpur districts. In each of these districts, 1-2 farmer fields will be selected. The trials will be laid out in RCB design with 4 replications. The seedbed nurseries will be covered by a 6cm thick layer of sawdust and then burned thoroughly. Poultry refuse and mustard oil-cake will be applied for eggplant in the main field at rate of 3 t/h and 300kg/h, respectively. (2) Management of soil-borne diseases of cucumber and tomato will be conducted in farmer fields at Kashimpur; cucumber during April -October 2001 and tomato during October 2001- March 2002. Both the experiments will be laid out in RCB design with 4 replications. The following treatments will be established for cucumber in unit plots of 2.5mX1m: (a) application of poultry refuse @ 10 kg/bed; (b) application of neem oil cake @ 1.5kg/bed, (c) application of furadan/rugby @25g/bed, (d) sawdust burning (6cm thickness),(e) application of mustard oil - cake @ 2kg/bed, and (f) untreated control. The tomato plots (5mX4m) will receive the following treatments: (a) application of poultry refuse @ 3t/ha, (b) application of neem oil-cake @ 200kg/ha, (c) application of rugby 10G @ 30kg/ha, (d) application of mustard oil-cake @ 300kg/ha, (e) Farmer practice, and (f) untreated control. Data will be recorded on different diseases and yields, and economic returns will be calculated.

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 eggplant, cucumber and tomato in the seedbed nursery as well as in the main field. A single approach would not be helpful to minimize disease complex of the crops. Application of organic amendments, saw dust burning, and nematicides would help to minimize the incidence of soil –borne diseases of eggplant, cucumber and tomato 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 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 eggplant, cucumber and tomato among the growers; (2) Reduced incidence of various disease pathogens; (3) Reduced dependence on chemical control; and (4) Higher yields of eggplant, cucumber and tomato.

k. **Projected start:** September 2001 for eggplant and tomato and July 2001 (on going) for cucumber.

l. **Projected completion:** September 2002 for cucumber and September 2003 for eggplant and tomato.

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

n. **Budget:** US$ 5775: BARI; $1100: AVRDC; $1155: Ohio State

II.5b Integrated Disease Management (IDM) to Control Leaf Curl Virus of Tomato

a. **Scientists:** M. Mozaffar Hossain, Harunor Rashid, Latifa Yasmin, Shahadat Hossain - BARI; M. S. Alam, A. Bashet - IPM CRSP; Sally Miller-Ohio State Univ.; L. Black-AVRDC

b. **Status:** New

c. **Objectives:** To determine the growth stage of the tomato plants critical for yellow leaf curl virus (YLCV) infection so that timely and effective control measures can be applied for better crop stand and higher yield. **Objective in 2001-2002:** To determine the growth stage of the tomato plants critical for vector infestation and YLCV transmission.

d. **Hypotheses:** Yellow leaf curl virus of tomato is a serious problem in Bangladesh. Total crop loss will occur if heavy disease infection is present. Pesticide use applied at other than the critical period of infection is not effective for controlling the disease.

e. **Description of research activity:** The experiment will be carried out at BARI farm, laid out in RCB design with 4 replications, involving the following treatments: T1 - Covering the seedlings in seedbeds with fine nylon net before transplanting; T2 - Covering the transplanted field with nylon net up to 30 days; T3 - Covering the transplanted field with nylon net up to 60 days; T4- Netting of the seedlings in seedbeds before transplanting and then pesticide sprays up to 30 days of transplanting; T5 - Netting of the seedlings in seedbeds before transplanting and then pesticide sprays up to 60 days of transplanting; and T6- Control (no netting or pesticide sprays). Vector infestation will be measured in each teratment.

f. **Justification:** TYLCV is a serious and widespread disease of tomato in Bangladesh. At present, no practical control measure is availabl e to the farmers. In the absence of a resistant variety, management tactics need to be developed to minimize crop losses.

g. **Relationship to other CRSP activities at the site:** Disease management tactics developed from this activity can be applied to other cases of disease problems and can also be complemented with other IPM measures.

h. **Progress to date:** New

i. **Projected outputs:** (1) Identification of the actual plant growth stage critical for TYLCV infection; (2) Better management of TYLCV in tomato; (3) Production of tomato with better quality and higher yield.

j. **Impacts:** (1) Minimized yield loss due to TYLCV; (2) Reduced pesticide use; (3) Increased yield with better quality of tomato.

k. **Projected start (month and year):** June 2001

l. **Projected completion (month and year):** November 2003

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

n. **Budget:** US$ 1650: BARI

III. Multidisciplinary Laboratory, Greenhouse, and Microplot Experiments

III.1 Study of Biology and Behavior of *Trichogramma* on *Leucinodes* Eggs under Laboratory and Field Conditions.

a. **Scientists:** S.N. Alam, M. Khordezzaman – BARI; Z. Islam – BRRI; N.S. Talekar – AVRDC; E. Rajotte – Penn State; A.N.M.R. Karim – IPM CRSP; 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 2001-2002:** (1) To rear the egg parasitoids in the labor atory and test their parasitism efficiency 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 th e population of eggplant fruit and shoot borer.

e. **Description of research activity:**

(1) 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 exi sting egg parasitoid species in the field.

(2) 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 i n 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 15-70 times per season; IPM will help to produce insecticide free vegetables 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 varietal screening for resistance/tolerance to FSB.

h. **Progress to date:** Identified the species that parasitizes *Leucindoes* eggs as being *Trichogramma chilonis* (Ishii). Have successfully reared *Trichogramma chilonis* on *Corcya.*.

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 2003

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

n. **Budget:** US$3190: BARI; $4445: Penn State; $635: Virginia Tech

IV. Socioeconomic Analyses

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

a. **Scientists:** M.I. Hossain, – BARI; A.Bashet – IPM CRSP; G. Shively – Purdue; G. Norton – Virginia Tech

b. **Status:** Continuing

c. **Objectives:** To (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. **In 2001-2002:** To evaluate the farm level and aggregate impacts of the latest IPM strategies developed on the project and write a paper out of the Debass thesis. Complete the optimization study (Mahmoud MS thesis) and write a paper reporting results from 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. A farm-level optimization model incorporating production (yield) and marketing (price) risks will be used to compare outcomes under selected IPM technologies to those obtained under farmer practices to study the incentives for 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 the three new technologies developed by IPM CRSP Bangladesh have been evaluated with an MS thesis 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 2003

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

n. **Budget:** US$ 2090: BARI; Virginia Tech: $11525

IV.2 Adoption of Integrated Pest Management Practices in Different Regions of Bangladesh

a. **Scientists:** M.I. Hossain, – BARI; A. Bashet – IPM CRSP; C. Sachs – Penn State; G. Shively – Purdue; G. Norton – Virginia Tech.

b. **Status:** Continuing

c. **Objectives:** To (1) understand the vegetable cropping pattern in Jessore, Manikganj and Gazipur, (2) assess the role of women in observed cropping patterns with specific foc us on homestead gardening, (3) determine patterns of gender division of labor in farm, household, and childcare responsibilities, (4) understand present practices of pest management for vegetable and other major crops, including the role of women, (5) asse ss women's role in post-harvest activities, (6) assess the role of homestead gardening in rural household food security in terms of nutritional status and health of children and women, (7) assess women, men, and children's perceptions of how pesticides aff ect health and environment, (8) assess structural factors in Jessore, Manikganj and Gazipur districts, i.e., infrastructure, NGO involvement, non -agricultural employment options, agricultural markets, agricultural employment within the village, pesticide m arketing, migration patterns, etc.

d. **Hypotheses:** (1) pesticide use increases with the commercialization of vegetable crops, (2) women are more involved in vegetable cultivation and homestead gardening than in other agricultural activities, (3) the input of women in deciding crop inputs is inversely proportional to the commercial value of the crop, (4) women use traditional non -chemical methods of pest control rather than chemical control, (5) labor -intensive IPM practices are adopted by farmers with adequate farm labor supply, (6) villages with higher NGO interaction are receptive to IPM.

e. **Description of research activity:** Data will be collected using focus groups, community surveys (village level), participant observations, household level interviews (interview husband and wife), and secondary data sources. To increase the variability, three or four villages will be selected from each district, i.e., a total of 9 -12 villages. The basic method of data collection will be in -depth interviews, administered at the household level. From 20-25 households within each village (selected randomly based on their economic situation – land holding), husbands and wives will be interviewed separately. Contents of the survey instrument will be designed with input from local NGOs and other agricultural development workers and farmers. To obtain information about village level structural factors, three or four key informants will be interviewed from each village. In addition, three or four focus group interviews will be conducted in each village, with men and women interviewed separately. Differences will be tested statistically and statistical methods will be used to describe the characteristics of the villages and respondents. Observed trends and patterns will be explai ned using multivariate analyses.

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:** Two papers (Hossain and Shively, et al.) have been prepared and submitted to academic journals in Bangaldesh. These focus on patterns and determinants of pesticide use by vegetable farmers. These papers are based on baseline survey data. Joseph Kodamanchaly, a PhD student in Rural Sociology and Demography at Penn State University was supported by IPM CRSP funds for his research work in Bangladesh. His research focused on gender issues in IPM adoption in Bangladesh. The following are outcomes of his research: (1) dissertation entitled "Women's Work, Household Decision-Making Process and Adoption of Integrated Pest Management: A Study in Rural Bangladesh." (Defending in July 2001); (2) policy paper entitled "Power Behind The *Purdah:* Women's Status, Household Decision-Making Process and Adoption of Integrated Pest Management in Rural Bangladesh." Paper presented to Population Reference Bureau, Washington DC; (3) poster presented at the IPM CRSP 2001 annual meeting at Va Tech.

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 2000

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

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

n. **Budget:** US$ 3465: BARI; Penn State: $9525

IV.3 Study of Price and Marketing of Vegetables and other Implications for Pest Management Practices.

a. **Scientists :** M.I. Hossain – BARI; A. Bashet – IPM CRSP; G. Shively – Purdue

b. **Status:** Continuing

b. **Objectives:** To (1) monitor and measure levels and variability of farmgate and wholesale prices for vegetables and relate to farm level data on crop and pest management decisions; (2) determine marketing costs and margins of different vegetables operated by different intermediaries; (3) study the market structure for commercial vegetable production, including actual and potential fresh vegetable exports; (4) monitor and measure export quantities of fresh vegetables; and (5) measure price premia for blemish-free vegetables. To date, twelve months of price data have been collected. Data collection is now complete and no additional data collection will be undertaken. Emphasis for the coming year will focus on data cleaning and analysis.

d. **Hypotheses:** (1) Farmers' crop and pesticide choices reflect risk avoidance strategies; (2) Pesticide use is higher for vegetables that receive a greater appearance premium in the market; (3) High marketing cost receive lower returns; and (4) Export potential increases the use of pesticides.

e. **Description of research activity:** Data will be collected from four locations viz. Jessore, Comilla, Dhaka and Gazipur. From each place, primary and secondary markets will be selected and concerned traders like bepari, aratdar (commission agent), wholesaler, retailer will be selected. From Dhaka city, stallholders from urban retail markets and some exporters from terminal markets will be selected for interview. A weekly survey of farmers will also be conducted to measure prices received for vegetables. Price data will be categorized according to mean and coefficient of variations on monthly and annual bases. Data on vegetable exports will be collected in cooperation with the Bangladesh Fruit, Vegetables and Allied Products Association.

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 of research.

g. **Relationship to other research activities at the site:** This work complements other socio-economic research on marketing in Bangladesh. Some information can be related to baseline study.

h. **Progress to date:** Collection of data from four districts is now completed. Partial analyses have been done. Preliminary results (simple descriptive statistics and graphs) show that price premia for unblemished vegetables are about 25% higher than the blemished ones. Analysis will continue focusing on statistical analysis of price data.

i. **Projected outputs:** Papers and presentations to research community and policy makers.

j. **Projected impacts:** (1) Better understanding of what drives crop choice and pesticide use; and (2) Improved targeting of research and policy interventions.

k. **Projected start:** March 2000

l. **Projected completion:** September 2002

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

n. **Budget:** US$ 3267: BARI; $33,885

IV.4 Integration and Diffusion of IPM Technology

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

b. **Status:** New

c. **Objectives:** To (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.

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:** New

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 for Rangpur and Comilla and January 2002 for Jessore.

l. **Projected completion:** September 2003

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

n. **Budget:** US$ 6127: BARI

SUMMARY OF RESEARCH ACTIVITIES - YEAR 9 WORK PLAN FOR THE ASIAN SITE IN BANGLADESH
(September 30, 2001 – September 29, 2002)

ACTIVITY	SCIENTISTS	BUDGET ($)
Baseline Survey and Crop/Pest Monitoring		
I.1 Monitoring of Pests and their Natural Enemies in Vegetables in Rice – Vegetable Systems	Z. Islam – BRRI; S.N. Alam, M.F. Zaman, M. Khorsheduzzaman, M.A. Rahman, M.I. Faruque, Anwar Karim, S.A. Khan – BARI; M.S. Alam, A. Bashet – IPM CRSP; L. Black – AVRDC; E. Rajotte – Penn State; A. Baltazar – NCPC/UPLB; S.K. De Datta, G. Luther – Virginia Tech	US$ 3,850: BARI/BRRI; $10,160: Penn State; $6,100: NCPC/UPLB
Multidisciplinary On-farm Pest Management Experiments		
II.1a Varietal Screening of Eggplant for Resistance to Bacterial Wilt, Fruit and Shoot Borer, Leafhopper (jassids) and Root-Knot Nematode and of Tomato for Resistance to Bacterial Wilt, Virus Disease and Root-Knot Nematode	Scientists: M.A. Rashid, M.M. Hossain, M.A. Rahman, Motiar Rahman, S.N. Alam, M.H. Rashid, M.I. Faruk – BARI; H.S. Jasmine, M. S. Alam, A. Bashet – IPM CRSP; L. Black, J.F. Wang, N.S. Talekar – AVRDC; G. Luther – Virginia Tech	US$ 5,500: BARI; $8,768: Ohio State
II.1b Pilot Production of Grafted Eggplants at Two Intensive Growing Areas (Jessore and Sripur-Gazipur) and Training of Farmers and Nurserymen	M.A. Rashid, Ataur Rahaman, A.K.M. Quamaruzzaman – BARI; M. Rafiquddin – RARS, BARI (Jessore); H.S. Jasmine, M.S. Alam, A. Bashet – IPM CRSP; G. Luther – Virginia Tech; L. Black – AVRDC	US$ 3,520: BARI; $1,705: Ohio State
II.1c Development of Eggplant Hybrids Resistant to Bacterial Wilt, FSB and RKN	M.A. Rashid, Motiar Rahman, A.K.M. Quamaruzzaman, M.M. Hossain, M. Nazimuddin – BARI; M.S. Alam, A. Bashet – IPM CRSP; G. Luther – Virginia Tech; L. Black, J.F. Wang – AVRDC	US$ 2,860: BARI; $4,705: Ohio State

II.1d	Screening of pumpkin germplasm against Watermelon Mosaic 2 Poty Virus (WMV2)	M.A. Rashid, M.A.T. Masud, M.H. Rashid – BARI; M.A. Mannan Akand – BSMRAU; H.S. Jasmine, M.S. Alam – IPM CRSP; G. Luther – Virginia Tech; L. Black, J.F. Wang – AVRDC	US$ 2,860: BARI; Ohio State
II.2a	Management of Lepidopteran Pests in Cabbage Using an Integrated Approach	S.M. Monowar Hossain, Salim Reza Mollik, M. Nazimuddin, S.N. Alam, M. Khorsheduzzaman – BARI; M.S. Alam, A. Bashet – IPM CRSP; N.S. Talekar – AVRDC; E. Rajotte – Penn State; G. Luther – Virginia Tech	US$ 3,630: BARI; $1,270: Virginia Tech
II.2b	Management of Cabbage Pests Using a Nylon Net Physical Barrier	S.M. Monowar Hossain, Salim Reza Mollik, M. Nazimuddi n, S.N. Alam, M. Khorsheduzzaman – BARI; M.S. Alam, A. Bashet – IPM CRSP; N.S. Talekar – AVRDC; E. Rajotte – Penn State; G. Luther– Virginia Tech	US$ 2,420: BARI; $6,985: Penn State:$1,270 : Virginia Tech; $1,705: Ohio State
II.2c	Assessment of Virus Infestation at Different Stages of Okra Plants	S.M. Monowar Hossain, Amir Hossain, Salim Reza Mollik, M. Nazimuddin, M. Khorsheduzzaman, K.A. Kader – BARI; M.S. Alam, A. Bashet – IPM CRSP; E. Rajotte – Penn State; G. Luther – Virginia Tech; S. Miller – Ohio State	US$ 2,510: BARI; $5,750: Penn State; $1,270: Virginia Tech
ll.2d	Off-season vegetable production under integrated pest management	S.M. Monowar Hossain, Salim Reza Mollik, Amir Hossain, M. Nazimuddin, M. Khorsheduzzaman – BARI; M.S. Alam, A. Bashet – IPM-CRSP; E. Rajotte – Penn State; G. Luther – Virginia Tech.; L. Black – AVRDC	US$ 3,080: BARI.
II.3	Determination of Cucurbit Fruit Fly (*Bactrocera cucurbitae)* Incidence Pattern and its Management in Sweet Gourd, Bitter Gourd and Cucumber Using Male an d Female Sex Attractants	M. Nasiruddin, S.N Alam, M.F. Zaman, M. Khorsheduzzaman – BARI; H.S. Jasmine, M.S. Alam – IPM CRSP; E. Rajotte – Penn. State; G. Luther – Virginia Tech; N.S. Talekar – AVRDC	US$ 2,750: BARI; $1,100: AVRDC

II.4 Crop Loss Due to Weed Infestation and Efficacy of Different Weed Control Methods	Anwar Karim, S.A. Khan – BARI; A.N.M.R. Karim, M.S. Alam, A. Bashet – IPM CRSP; A. Baltazar – NCPC/UPLB; S.K. De Datta – Virginia Tech	US$ 2,640: BARI; $6,100: NCPC; $2,540: Virginia Tech
II.5a Integrated Management of Soil-Borne Pathogens of (a) Eggplant in the Farmer Field in Jessore and Jamalpur, and (b) Cucumber and Tomato at Kashimpur	M.A. Rahman, K.A. Kader, M.I. Faruk – BARI; M.H. Hossain – RARS, BARI (Jessore); M.M. Hossain – RARS, BARI (Jamalpur); H.S. Jasmine, M.S. Alam – IPM CRSP, S. Miller – Ohio State; L. Black – AVRDC	US$ 5,775: BARI; $1,100: AVRDC; $1,155: Ohio State
II.5b Integrated Disease Management (IDM) to Control Leaf Curl Virus of Tomato	M. Mozaffar Hossain, Harunor Rashid, Latifa Yasmin, Shahadat Hossain - BARI; M. S. Alam, A. Bashet- IPM CRSP; Sally Miller-Ohio State Univ.; L. Black- AVRDC	US$ 1650: BARI
Multidisciplinary Laboratory, Greenhouse, and Microplot Experiments		
III.1 Study of Biology and Behavior of *Trichogramma* on *Leucinodes* Eggs under Laboratory and Field Conditions	S.N. Alam, M. Khordezzaman – BARI; Z. Islam – BRRI; N.S. Talekar –AVRDC; E. Rajotte – Penn State; A.N.M.R. Karim – IPM CRSP; G. Luther – Virginia Tech	US$3,190: BARI; $4,445: Penn State; $635: Virginia Tech
Socioeconomic Analyses		
IV.1 Measure Economic Impacts of Bangladesh IPM CRSP Research Activities	M.I. Hossain, – BARI; A.Bashet – IPM CRSP; G. Shively – Purdue; G. Norton – Virginia Tech	US$ 2,090: BARI; Virginia Tech: $11,525
IV.2 Adoption of Integrated Pest Management Practices in Different Regions of Bangladesh	M.I. Hossain, – BARI; A. Bashet – IPM CRSP; C. Sachs – Penn State; G. Shively – Purdue; G. Norton – Virginia Tech	US$ 3,465: BARI; Penn State: $9,525
IV.3 Study of Price and Marketing of Vegetables and other Implications for Pest Management Practices.	M.I. Hossain – BARI; A. Bashet – IPM CRSP; G. Shively – Purdue	US$ 3,267: BARI; $33,885

IV.4 Integration and Diffusion of IPM Technology	M.I. Hossain, S.N. Alam, M.A. Monayem Miah, M. Nazrul Islam – BARI; M. Ataur Rahman – CARE-Bangladesh; G. Shively – Purdue; G. Norton, G Luther – Virginia Tech; Madonna Casimero – IRRI	US$ 6,127: BARI

Ninth Year Workplan for the Caribbean Site in Jamaica

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 9 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 vegetable crop (with emphasis shifting from callaloo to crucifers). Essential IPM elements (sampling, monitoring, host-plant resistance, biorational pesticides with integrated resistance management, disease management integrated with insect vector management) are being emphasized in specific cropping systems where they offer the most rapid gains. These elements are also being integrated within cropping systems (e.g., sampling is integrated with biorational pesticides and resistance management in leafy and cruciferous vegetables, and sampling/monitoring with host-plant resistance and disease management in hot peppers).

Reduced production and productivity of hot pepper due to virus problems have been partially managed through introduction of the virus-tolerant West Indian 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 callaloo production, high pesticide use against lepidopterous pests is widespread. Therefore fresh and processed export products of callalloo are frequently tested by major markets to determine residue levels present . IPM-CRSP-funded research has devised a threshold-based sampling and pesticide use plan, as well as new pesticides, for reducing pesticide use which would lead to a reduction of interceptions of produce with unacceptable levels of pesticides. This system developed to rationalise pesticide use is being validated, regionalised and applied to crucifer crops another vegetable crop with high-pesticide use. Farmers are being trained throughout the region. Pesticide residue testing will begin, using newly institutionalized in country facilities.

Sweetpotato pest management plans involve resistant varieties and biorationals for grub and weevil control, and 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 is proposed for year 9.

The program is creating institutional linkages across the Caribbean (such as the evolution of PROCICARIBE) 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 Institute; 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, four 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, and Virginia Tech in virus-vector management, economics, and GIS/GPS systems for pest management. Several short-term training activities involving all institutions are planned for Year 9.

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 management systems for hot pepper, sweet potato, and leafy vegetables, *Amaranthus* [callaloo] and cabbage. These 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 eliminating these highly toxic materials. The first phase is to demonstrate that the rationalized use (threshold-based) use of 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. Several components of hot pepper pests have been addressed separately, but require integration across pests for sustainable pepper production. Individual continuing and new projects follow. New projects are proposed for year 9 in cabbage and sweet potato, and a new collaborator at U.W.I. for hot peppers. In year 9 we finish the implementation phase for callaloo, and transition to another high-input-insecticide crop such as crucifers, with an emphasis on cabbage, at a regional level.

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

a. Scientists: Dionne Clarke-Harris, Frank D McDonald – CARDI; Phillip Chung – RADA; Shelby Fleischer – Penn State Univ.

b. Status: Continuing activity, with activities.

c. Objectives:

<u>Overall</u>: (1) To apply the 'Callaloo Research Model' (threshold-based management) in the development of an IPM strategy for major pests of crucifers; (2) To regionalise the IPM systems approach for high-pesticide-input vegetable systems.
<u>Specific</u>: (1) Determine the best IPM strategy to manage the lepidopteran complex on callaloo in two major agroecological zones in Jamaica; (2) Train extension officers in major growing areas in callaloo pest management; (3) Initiate regionalisation of the threshold-based pesticide management model and its applicability to other vegetable crops; (4) Train researchers in two Caribbean islands in 'Callaloo Research Model' and its application to other vegetable systems; (5) Determine major pests on cabbage; (6) Develop sampling protocol for two major lepidoptera species on cabbage; (7) Monitor populations of two major lepidopterous pests on cabbage; (8) Evaluate biorationals on major lepidoptera on cabbage; (9) Guide parallel studies (objectives 4-8) in the two selected Caribbean islands.

d. **Hypotheses:** (1) Potential of IPM strategies to manage the lepidopteran complex on callaloo is dependent on agroecology. (2) Training extension officers in callaloo IPM technology will greatly assist in the implementation of an islandwide programme for Jamaican farmers. (3) The pesticide use management model developed for managing lepidoptera pests on callaloo has relevance to other cropping systems which lack protocols for timing the application of pesticides. (4) The research model used to develop an IPM strategy for the vegetable amaranth system is applicable to other high-pesticide-input vegetable systems e.g. crucifers, in the Caribbean; (5) Lepidoptera species are the major limiting pests on cabbage; (6) Spatial and temporal distribution of lepidopterous pests on cabbage have specific sampling requirements; (7) Populations of lepidoptera species on cabbage fluctuate throughout the growing season; (8) New biorational chemistries which were effective against lepidoptera on Callaloo will have similar efficacy against major lepidoptera species on cabbage and other crucifers; (9) Cropping systems of cruciferous vegetables in the Caribbean have similar characteristics which allow for easy regionalisation of developed IPM technology.

e. **Description of Research Activity:**

<u>Jamaica</u>
(1) Determination of the best IPM strategy to manage the lepidoptera complex on callaloo in two major agroecological zones and seasons in Jamaica, in relation to crop phenology. From data collected on the population dynamics of the lepidoptera complex, distinct seasonal differences were identified – *low populations (cool temperatures - December to March) and high populations (hot temperatures - June to November).* Evaluation of two IPM strategies (threshold-based management and exclusion) started in Year 7 will be completed on each of 6 farms in two major callaloo-growing areas to determine their cost-effectiveness. The parameters to be measured include pest incidence and damage. Economic analysis of the strategies will be conducted for the two seasons. (1) Pest Incidence - Plots will be scouted once weekly. Cumulative number of larvae on 25 randomly selected plants per plot will be recorded; (2) Pest damage – crop will be sorted into categories (no damage, insect (>30% feeding holes), fungal and mechanical damage, physiological defects) and weighed; (3) Economic analysis – cost of inputs (row

covers, agrochemicals, labour - land preparation, weed management, harvesting, irrigation) as compared to marketable yields and price.

(2) Integration and Implementation of Management Components. This is a continuing activity. Plots established and used to demonstrate callaloo IPM technology to extension officers (RADA) and callaloo farmers in Year 7 will be maintained for ongoing training in Year 9. The strategies demonstrated will include: (a) Covering rows with agronomic fabrics, in combination with cultural practices; (b) Using pesticides in combination with cultural practices. Pesticides will be applied within the framework of a resistance management programme (rotation of chemicals and the use of a sequential sampling plan to time applications).

(3) Training materials developed during Year 4 and Year 5 will be used in training exercises. Information from these workshops will be used to refine and develop educational activities for farmers, and used as part of the wider implementation efforts. Technology to be demonstrated includes the rationalized use of new biorational pesticides using a threshold-based sampling plan and decision-making tool and pesticide rotation.

(4) Regionalisation of the Threshold-Based Research Model. The research approach to the development of the classical IPM strategy developed for callaloo comprising sampling, decision making based on an action threshold, and the use of biorationals and nonchemical alternatives which promote the conservation of natural enemies will be documented and used in training workshops conducted in two selected Caribbean islands.

Caribbean Region

(1) Training of researchers in two Caribbean islands in the Threshold-Based Research Model and its application to other vegetable systems.

Two workshops, one in each of two selected Caribbean islands will be held to outline the steps of 'Callaloo Research Model'. The research model used in the development of the classical IPM approach for callaloo which, comprises sampling, decision making based on an action threshold, and the use biorationals and nonchemical alternatives will be applied to the cabbage system to develop an IPM strategy for major economic pests on this crop and other crucifers.

(2) Determination of major pests on crucifers in the Caribbean.

Baseline surveys will be conducted in Jamaica and the two selected Caribbean islands to record the incidence and economic importance of major pests on crucifers.

(3) Development of sampling protocol for two major lepidoptera species on cabbage.

The distribution of two most important lepidoptera pests will be investigated within cabbage fields and suitable sampling units and frequency of sampling determined for two phenological stages of the crop. The sampling protocol will be developed based on within-plant and within-field distribution of the pests.

(4) Monitoring populations of two major lepidopterous pests on cabbage.

The population levels of the two selected lepidoptera species will be monitored on four farmers' fields over two cropping seasons and peak and low pest seasons identified. Data collected will be compared with secondary data available to substantiate fluctuation patterns observed.

(5) Evaluate biorationals on major lepidoptera on cabbage.

The efficacy of four biorational pesticides will be evaluated in randomised complete block experiments over two seasons.

(6) Execution of parallel studies (2-5) in two selected Caribbean islands. Research collaborators will be identified in two selected Caribbean islands during regionalisation training workshops. These collaborators will conduct similar studies described above (2-5) to generate data on situations on these islands in order to guide the development of appropriate strategies for each country. Areas of variability among islands will be noted for extrapolation to other islands.

f. **Justification:** Synthetic chemicals currently used are resulting in field failures, and the development of pesticide resistance is highly probable based on results of initial bioassays conducted in Year 5. New biorational materials 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 suggest that they will be effective in the presence of a population of lepidopteran larvae that are resistant to carbamates, phosphates or pyrethroids. These materials also improve farm-worker safety, and may result in significant conservation of natural enemies when deployed at a farm scale. Maintaining registrations on biorationals through the processes that are anticipated with respect to changes due to the Food Quality Protection Act of 1996 in the United States is more feasible and they produce no hazardous residues.

One emphasis in Year 7 was to determine the feasibility of using various IPM strategies under contrasting agroecologies. This is critical for assisting farmers to make pest management decisions based on the economics (profit, marketing, pest pressure, IPM strategy). In addition, training of extension officers as field scouts will assist with the islandwide implementation of the scouting programme. This training, which intensified in Year 8, will continue into the first half of Year 9.

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

In Year 8 some emphasis has been placed on fulfilling the objective of the IPM CRSP, which is to regionalise IPM technology developed in primary sites to other countries in the designated region. The crucifers have been identified as a vegetable system, which is universal to the Caribbean and plagued with pest and pest management problems similar to the vegetable amaranth studied in Jamaica. From among the 16 member countries of the Caribbean IPM Network 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.

g. **Relationship to other CRSP activities at the site:** The main thrust for year eight is geared towards validation and implementation of the IPM model developed for rationalized pesticide use in management of lepidoptera on callaloo. Successful demonstration of this system would be the justification for its use in other cropping systems where injudicious use of pesticides occurs. The application of this model to Integrated Management of pests affecting cruciferous vegetables will be the focus of regionalisation activities in Year 9. IPM systems development on all commodities (hot pepper, vegetables and sweetpotato) is now at the regionalisation phase. These activities can therefore be promoting all the developed strategies to the various groups of farmers targeted during training sessions. Farmers would therefore be exposed IPM in its broadest sense as the strategies developed for each commodity has a different focus based the principles of IPM.

h. **Progress to date:** During Years 1-6 high levels of damage have been documented in spite of pyrethroid applications, and completed bioassays from field-collected larvae using methods modified for local work. Together, the results show a strong probability that populations are resistant to ?-cyhalothrin. Small plot trials continue to demonstrate dramatic increases in management of lepidopterans on callaloo with new biorational chemistries (spinosad, tebufenozide and emamectin benzoate) and cultural techniques (exclusion with agricultural fabrics) during validation studies. 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) developed in Year 6 and pesticide rotation. The development of exclusion as a management tactic progressed with the selection of a barrier material, which would allow optimal growth, and development of the crop. On-farm validation was initiated in Year 7 and will continue for the current year into the first half of Year 9.

With the fungal leaf pathogen, we remain at the first stage of an IPM system development – identification and taxonomy of the pathogen. It has only been possible to monitor the severity of the leaf pathogen in three callaloo growing areas for one season. This will be repeated to determine seasonal changes. The use of exclusion cages was found to effect a reduction the infection by this pathogen and will be evaluated for the potential role of exclusion barriers in the management of this disease. CARDI has recently provided funding to upgrade laboratory facilities to enable the execution of this work.

i. **Projected Outputs:** (1) Protocol handbook on timing pesticide application for lepidoptera pests on callaloo; (2) Manual on the Best Management Practices in callaloo production at the pre and post harvest stages; (3) Manual on research approach to the development of IPM model for callaloo systems; (4) A system to effect rationalised pesticide use against lepidopterous pests of cabbage; (5) IPM researchers trained in a research approach to IPM system development.

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 control options, with enhanced farm worker safety and reduced food safety concerns due to pesticide residues and 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 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. We also expect the use of IPM in callaloo to reduce the number of export rejections due to pesticide residues and the presence of arthropod pests. The work that has been conducted on callaloo is pioneer work in vegetable IPM in the Caribbean, because of the polyphagous nature of the lepidopteran complex being addressed on the crop the technologies being developed will have relevance to other vegetable systems in Jamaica and the Caribbean. The classical nature of this IPM model also makes it applicable to other cropping systems with excessive pesticide input.

Lepidopterous pests attacking cabbage and other crucifers in the Caribbean have exhibited the 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 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:** September 1995 for continueing work; September 2001 for new work.

l. **Projected completion:** September 2002 and September 2003

m. **Projected person-months of scientist time per year:** Scientists, 7 months + Technicians, 10 months (CARDI); 1.5 months (Penn State)

n. **Budget:** IPM CRSP: $20,6800– CARDI; $1,202 – Penn State; 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, Lilory McComie – CARDI; Don McGlashan – MINAG; Phillip Chung – RADA, D. Michael Jackson, Janice Bohac – USDA; Clive Edwards – Ohio State University.

b. **Status:** Continuing Activity

c. **Objectives:** (1) Evaluate the potential of resistant varieties and biorationals (insect growth regulators, entomopathogenic nematodes, fungi and bacteria) for managing sweetpotato weevils, sweetpotato leaf beetle, and other soil insect pests; (2) Evaluate the potential of dry-flesh USDA, Jamaican, and OECS pest-resistant sweetpotato lines under Caribbean growing conditions; (3) Regionalize sweetpotato weevil IPM technology within selected countries within the Caribbean through demonstration and training.

d. **Hypotheses:** (1) Biorationals (insect growth regulators, entomopathogenic nematodes, fungi, BT) are potential IPM tactics for reducing sweet potato weevil and sweetpotato leaf beetle larval populations and damage; (2) Differential tolerance to pest attack exists in sweetpotato breeding lines (USDA and OECS); (3) Pheromones and cultural practices will be effective against sweetpotato weevil populations in various countries within in the Caribbean; (4) Host plant resistance, biological control, and cultural measures can be used as components of an IPM program to control pests and diseases and lessen the impact of chemical insecticides.

e. **Description of Research Activity:**

USA

(1) Efforts will continue at the U. S. Vegetable Laboratory to develop dry-fleshed sweetpotato cultivars with multiple pest resistance using resistant parents in a polycross breeding system. Greenhouse tests will be conducted to evaluate breeding lines for resistances to root-knot nematodes and *Fusarium* wilt; and breeding lines will be evaluated in field tests at Charleston, SC, for insect resistance and at Blackville, SC, for yield, quality, and appearance (Bohac & Jackson). Additional red-skinned, cream-fleshed sweetpotato clones that are candidates for release as cultivars will be sent to Jamaica and St. Kitts in 2001. The USDA collaborating entomologist (Jackson) will visit Jamaica and St. Kitts to assist cooperators with the collection of data on insect resistance, in the evaluation of biorational materials for managing the sweetpotato leaf beetle and other insect pests of sweetpotato, and in the regionalisation of IPM technology in the eastern Caribbean.

Jamaica

(1) Evaluation of the efficacy of selective chemicals, insect growth regulator (Imadaclopríd, Mach 2®), **botanical** (garlic repellent) and **resistant varieties** (Picadito, White Regal, and two Jamaican varieties) to reduce weevil and grub populations will be evaluated. The crop will be grown with agronomic practices used by farmers. Treatments will be allocated in a randomized complete block with 4 replicates, 50 plants per treatment (n = 600). Parameters measured will include: pest incidence (pre and post treatments) and crown/root damage (weevil – scale of 1 - 5 based on degree of surface and internal damage; leaf beetle larvae – scale of 0 - 4 based on the length of tunneling). Where entomopathogens are used, their ability to recycle in the soil will also be determined.

(2) Evaluation of Potential USDA and Jamaican Sweetpotato Varieties for Yield, Market Acceptance and Insect Resistance. Efforts will continue to develop dry-fleshed, red-skinned sweetpotato cultivars with multiple pest resistance for potential use in the Caribbean. The focus will also be on refining the technology package by identifying the most promising USDA lines with acceptable characteristics (i.e. dry-fleshed, red-skinned sweetpotato cultivars with multiple pest resistance), together with Jamaican varieties and using them in varietal trials to confirm/verify their tolerance to the pests. Greenhouse tests will be conducted to evaluate breeding lines for resistances to root-knot nematodes and *Fusarium* wilt; and breeding lines will be evaluated in field tests

at Charleston, SC, for insect resistance and at Earhart, SC, USA, for yield, quality, and appearance. 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 2001. Local varieties and USDA/Clemson lines will be evaluated in field trials in Jamaica and St. Kitts & Nevis. 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 (weevil – scale of 1 - 5 based on degree of surface and internal damage; leaf beetle larvae – scale of 0 - 4 based on the length of tunneling). Treatments will be allocated in a random complete block design with four replicates with stands of 25 plants.
(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 be disseminated to other parts of the island and to selected countries in the Caribbean (St Vincent, St Lucia, Antigua, St Kitts). In Jamaica, demonstration and training will continue to focus on sweetpotato weevil and sweetpotato leaf beetle. Five demonstration farms will be established using the typical agronomic practices utilized by farmers within the island 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.

Interactive IPM workshops will be conducted with farmers, technicians, extension personnel, etc. on sweetpotato pest management of the Caribbean, to include white grub, sweetpotato weevil, leaf beetle and other pests.

St Kitts and Nevis

(1) Evaluation of Potential USDA and OECS Sweetpotato Varieties for Yield, Market Acceptance and Insect Resistance. On each island seven USDA and six OECS sweetpotato lines will be evaluated for insect resistance (especially for sweetpotato weevil), 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.
(2) Demonstration and Training in Sweetpotato IPM Technology See methodology for Jamaica.

St Vincent

(1) Baseline Survey and Component Testing. In St Vincent the West Indian Sweetpotato Weevil, *Euscepes postfasciatus,* is present instead of *Cylas formicarius*. The emphasis will be on the development of an IPM system for this pest based on the Jamaican experience. A baseline survey, evaluation of a monitoring system and some selective chemicals and microbials will be the initial focus. Between ten and fifteen

sweetpotato lines already present in the island will be evaluated using methods described for Jamaica.
(2) The IPM technology developed in Jamaica will be evaluated in a small pilot test consisting of 5 farms using our best IPM practices and 5 farms using traditional production techniques. At harvest, the effect of the introduced technology on weevil population, root damage and improvement in marketable yields will be measured. Strains of *Beauvaria bassiana* will be evaluated for efficacy on *E. postfasciatus*. This work will be done in cooperation with Aziz Lagnaoui (CIP, Lima, Peru). Dr. Jackson will visit the laboratory of Dr. Lagnaoui to help coordinate this effort.

f. **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 emergence 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, *Euscepes postfasciatus* Over the past two cropping seasons, the selective chemical fipronyl and varieties, which may be tolerant to weevil and soil grub attack, have been identified. These tactics are therefore being evaluated for an additional season. Biorationals such as entomopathogenic fungi and nematodes and 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 within 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 7 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: Local varieties TIS30-30, TIS24-98 and Fire-on-Land, USDA varieties White Regal, Picadito, and W308. In evaluating the efficacy of a low-persistence insecticide (fipronyl) or botanical extract (garlic) against the leaf beetle, the pest incidence was generally low. Initial observations are that both chemicals performed equally well.

In the US, significant progress was made in developing high yielding, multi-pest resistant, red-skinned, white-fleshed sweetpotato clones. Nineteen USDA lines (including White Regal) were sent to Jamaica and St Kitts from USDA, South Carolina where they were evaluated in varietal trials. Released multi-pest resistant sweetpotato breeding lines and cultivars (W-274, White Regal, Ruddy, Patriot).

Workshops were held in Linstead, St Catherine and Ebony Park, Clarendon in Jamaica. Forty-two sweetpotato farmers and extension officers were trained in the sweetpotato weevil IPM technology. One field day was held on a demonstration plot in Old Harbour, St Catherine at which 23 farmers and extension officers participated. The regionalisation of sweetpotato IPM was a major focus in Year 7 and continued in Year 8.

St Kitts

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. A repeat trial was established in March 2001 with 10 USDA and 5 local varieties. As part of the demonstration and training in sweetpotato IPM technologies, two farmers were involved. They made pheromone traps, set them out in their fields and maintained them for the duration of the crop. Weekly catches of weevils were recorded to demonstrate effectiveness of trap.

Antigua

At a workshop in November 2000, farmers and extension officers were informed of the cultural practices effective against the sweetpotato weevil and they were also trained in the making of homemade traps. The farmers showed great enthusiasm in carrying out varietal resistance trials.

St Vincent

Twenty-seven extension officers and farmers participated in a two-day training workshop held in November 2000. Extensionists were trained in the assessment of damage to stems and tubers due to different pests construction of pheromone traps using plastic containers Farmers were trained in the identification of weevil, grub and rat damage, application of different complementary cultural practices effective against sweetpotato weevils and the construction of pheromone traps using plastic containers. The participants were very receptive about the information imparted was shared. The population dynamics of the weevil present in St Vincent (*Euscepes* sp.) need to be studied in order to refine an IPM strategy for that pest. The conduction of a baseline survey was fully supported by the

Ministry of Agriculture and is being carried out. Varietal trials are expected to be established within the next two months

<u>Nevis</u>
Eighteen farmers and extension officers participated in workshop held in March 2001. Information imparted to participants on the different pests of sweetpotato, how to identify damage by these pests, how to reduce damage to crop by these pests. Participants were given a practical demonstration of the construction of traps and their placement in the field and were also able to observe the efficacy of traps. The response of the farmers to the training was very encouraging and their increased understanding of the pests and their management was obvious.

i. **Expected output:** (1) Improved capability to forecast pest incidence and recommend IPM strategies for the research crops; (2) Increased tactics available for IPM package improving sweet potato 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. **Expected 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:** October 1998

l. **Projected Date of Completion:** September 30, 2002

m. **Projected Person-Months of scientist time per year:** 1

n. **Budget:** IPM CRSP: $ 12,100 – CARDI; $ 13, 970 – USDA; Other: personnel costs-CARDI, OSU, USDA (Scientist's time)

I.3 Assessment of Virus Incidence in Superior Caribbean Sweet Potato Varieties

a. **Scientists**
Kathy Dalip – CARDI; D. Michael Jackson- USDA-ARS Vegetable Laboratory;
Sue Tolin - Virginia Tech.

b. **Status:** New Activity

c. **Overall Objective**: Consistent with development of sweet potato 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 sweet potato viruses. Purchase antiserum or virus-testing kits, and train CARDI researchers in methodologies of sampling and testing for viruses. Specifically test the varieties that have been shown to perform well and resist major insect pests. Varieties which may be included, based on their resistance to insect pests are: Local varieties Tis30-30, Tis24-98 and Fire-on-Land, and USDA varieties White Regal, Picadito and W308. Observations will be made of sweet potato performance and symptoms associated with the main viruses that are detected. The need for a virus detection program in the propagation of sweet potato mother plants will be assessed and whether selection of plants free of damaging viruses for distribution to farmers will increase sustainability.

f. **Justification:** Worldwide, viruses have been shown to have effects on the yield and productivity of sweet potato. Major ones include sweet potato feathery mottle virus strains. There is currently no knowledge of virus status of the local Jamaican varieties. Although none 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:** Sweet potato has been a crop examined in the IPM-CRSP since the beginning of the project. IPM strategies have been developed and implemented for sweet potato weevil and soil grubs. Superior varieties have been identified. Elimination of viruses from these varieties will complement this activity.

h. **Progress to date:** N.A.

i. **Projected Output:** Information on the incidence of sweet potato viruses in Jamaican varieties.

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 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:** None allotted in regular funding. CARDI and UWI: Supplies; sampling; testing. USDA: Germplasm identification and sampling; methodologies for testing; virus elimination. VT: Design of experiments, identification of availability of testing for viruses; training.

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

a. **Scientists:** Frank McDonald, Dionne Clarke-Harris**,** Kathy Dalip, Raymond Martin – CARDI; Don McGlashan, Juliet Goldsmith – MINAG; Phillip Chung – RADA; Clive A. Edwards, Matt Schroeder (Graduate Student) – OSU; 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) Perfect the method of assessment of broad mite populations and extend it to cover broad mite predators and parasites; (7) Train CARDI/MINAG scientists in the taxonomy of broad mite and broad mite predators; (8) Further test biorationals, low environmental impact acaricides, and a fungicide, for effects on broad mite incidence, fungal incidence and natural enemy populations; (9) Identify broad mite vectors, e.g. aphids, in Jamaica and spread of infection in the crop; (10) Continue studies on the relative incidence of broad mite in sprayed and unsprayed fields and identify pesticides responsible for killing natural enemies; (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 will minimise damage to natural enemies and better control broad mite; (7) Increased attacks by broad mite in recent years are due to suppression of natural enemies by acaricides and insecticides; (8) Damage by broad mite is increased by transmission of a fungus that causes necrotic lesions on the foliage; (9) Aphids may be a phoretic vector for transmission of broad mites between and within crops.

e. Description of Research Activities:

(1) Characterization of Virus Complex. In order to validate the 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 biology 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 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. Model components for which risk indices will be developed in year 9 are application of stylet oil, reflective mulch, straw mulch, and combinations of stylet oil and aluminum and straw mulches. 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. Use of Barrier crops and removal of virus/vector sources will be evaluated in year 10.

(5) Biotechnology-enhanced development of virus resistance: (NEW)

(a) *Genetic resistance:* MINAG scientists have an on-going program to select for virus resistance from crosses of Scotch Bonnet pepper with other peppers known to have resistance to TEV. Training in virus identification and assessment methods will be given by VT on a short-term basis in this area. The use of molecular marker-assisted selection will be explored to enhance the process.

(b) *Pathogen-derived resistance:* In this process, a portion of the viral genome is engineered into the pepper genome, providing a nucleic-acid-based resistance. We will begin the first steps of this process, namely developing candidate sequences of the virus for insertion; and establishing a tissue culture protocol for plant regeneration that is a prerequisite for genetic engineering. As no work to date had been done on regeneration for Scotch Bonnet peppers, methodology for closely related plants such as bell pepper (*Capsicum annum)* will be utilised initially to see if it is applicable to *Capiscum chinense* cv. Scotch Bonnet. There are reports in the literature on successful regeneration of bell peppers showing shoot formation from rooted hypocotyls, and even regeneration following wounding at specific sites.

(c) *Induced systemic resistance:* In initial experiments at U.W.I., six indigenous bacteria isolated from pepper rhizosphere and a *Pseudomonas putida* strain were evaluated for their ability to promote growth and induce resistance to potyvirus (likely either TEV or PVY) in pepper cv. Scotch Bonnet. In our screening experiments growth parameters evaluated were stem length and shoot dry weight up to 8 wk in a plant growth chamber with diurnal conditions set at 16 h light, 8 h dark at 28°C and 24°C, respectively. Two isolates, *P. putida* and *Bacillus* sp. (UWI-3) significantly increased stem length by 57% and 30%, respectively (p>0.05). Four isolates, *P. putida*, *Serratia marcescens* (UWI-2), *Bacillus* sp. (UWI-3), and an uncharacterized isolate (UWI-5) increased shoot dry weight by 46%, 17%, 77%, and 79%, respectively (p>0.05). Plants inoculated (bacterized) with

[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

P. putida and *Bacillus* sp. (UWI-3) were more tolerant to potyvirus infection than non-bacterized plants. Bacterized plants had delayed symptom development and greater plant growth compared to the non-bacterized and potyvirus inoculated control plants. Work will be continued on this effort using characterized isolates of TEV and PVY, and will be related to previous plant nutrition experiments.

(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. A U.S graduate student from OSU competent in mite taxonomy, will visit Jamaica for 7-10 days. He will provide advice and training in mite taxonomy for Kathy Dalip, Juliet Goldsmith, and other personnel. This will cover the mites that are predators of broad mite. One person from CARDI or MINAG will be selected for broader training in mite taxonomy and sent to the International Training course (3 weeks) in mite taxonomy. This is held at OSU in late June early July annually.

(8) Effects of biorational pesticides on populations of broad mites and their natural enemies. The biorational pesticides shown to be most effective against broad mite in Year 8 will be tested again, together with new ones, and a fungicide in Year 9, with the focus not only on broad mite control but also on the effects of the pesticides on natural enemies of broad mite. The aim is to identify those pesticides with least effects on natural enemies that can be used in an IPM program. Assessments will also be made of the incidence and spread of fungal infections due to broad mite feeding.

(9) Broad mite vectors. Whiteflies, aphids, and other potential vectors of broad mite will be collected in yellow water traps and on yellow sticky traps and examined for broad mites clinging to them. These studies will be in known areas of high broad mite incidence.

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. Research activities will investigate factors that promote large broad mite populations and means of controlling them as component of an IPM strategy for hot pepper.

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 for all three pests. For example if broad mites are transmitted by aphids, 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 regionalisation 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 it was demonstrated that those farmers that used most pesticides had the highest incidence of broad mite. This has pinpointed the need for controlled use of pesticides that do harm the natural enemies of broad mite.

i. **Projected output:** (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 management of broad mite, as part of an overall IPM for hot pepper, will be developed; (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.

k. **Projected Start:** October 1998

l. **Projected Date of Completion:** September 28, 2003

m. **Projected Person-Months of scientist time per year:** 12

n. **Budget:** IPM CRSP: $ 31,350 – CARDI; $ 2,400– MINAG; $ 2,835 – OSU; $ 4,386 - VA TECH

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; Florence Young, Carol Thomas – MINAG; Phillip Chung, Janette Lawrence – RADA; 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 (?-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 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 pests 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:** Over the past year much focus has been placed on the biology of the pest complex and gathering baseline data to analyze the influence of agroecological factors and farm management practices on the distribution and density of the pest complex islandwide. Data have been gathered from over 160 farms throughout the island. Some of the data have been entered into a GIS system and initial analyses have been carried out which provide information to direct future studies. Confirmatory identification of the composition of the gall midge complex will be completed in Year 9 with the submission of samples, which were collected from multiple locations islandwide. Fumigation trials with Magnesium phosphide have been conducted and conclusive results will be available by end of the current year. There have been significant advances in the development and implementation of a traceability system for tracking pest-free and 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.

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 date of completion:** September 28, 2002

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

n. **Budget:** IPM CRSP through Technical Assistance: $ 18,700 – CARDI, with subcontracts to members of the Gall Midge Taskforce; US-AID Jamaica Mission: $ 5,100 – Virginia Tech.

II. Pesticide Use and Residues

II.1 Persistence and Non-target Effects of Pesticides on Hot Pepper and Leafy Vegetables in the Tropics

a. **Scientists Names and Institutions:** Clive A. Edwards (OSU), Frank McDonald (CARDI), Dwight Robinson (Univ. West Indies), Kathy Dalip (CARDI).

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

c. **Overall Objectives:** The intent of this topic is to assess the extent to which pesticides are used on pepper, callaloo and sweet potato. We hypothesize that many of these pesticides can be detected in local and export market marketplaces. Thus, the activities described below attempt to quantify pesticide use and residues that can either cause human health problems or rejection in the marketplace. Resistance to pesticides may also be the result of excessive pesticide use or use of those chemicals that degrade very slowly under field conditions. In Year 9 work will focus on elements of pesticide risk analyses on the more popular pesticides used on callaloo and hot pepper 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 Mona Campus of the University of the West Indies (UWI) in Jamaica, the major agency for the development of capabilities pesticide residue analysis and toxicological research for the region. Work proposed will assist pioneer efforts toward ISO HAACP systems development within the region.
Specific Objectives: (1) To ensure that hot peppers for export, or local sale, are not contaminated with pesticides; (2) To ensure that pesticides used on hot peppers do not have adverse effects on soil invertebrates and soil processes; (c) To develop local capabilities for pesticide residue analysis and coordinate in-country capabilities.

d. **Hypotheses:** (1)Hot peppers for export may have pesticide residues at levels that would restrict import into the U.S.; (2) 'Half life' values for pesticides under tropical Caribbean conditions will differ from those in temperate climates; (3) Some pesticides are more persistent on foliage and in soil than others.

e. **Description of Research Activities**
Pesticide persistence on plants. The persistence of the most commonly used pesticides fipronyl, imidacloprid, ?-cyalothrin, diafenthuron and profenofos, 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. Fruit samples will be taken at 0, 3, 7, 14 and 21 days after pesticide application, extracted and analyzed by GLC to determine T_{50} values

Pesticide persistence in soil. The soil in small plots 2 m x 2 m will be treated directly with the same insecticides and pesticide residues and analyzed 2 weeks, 4 weeks and 8 weeks after pesticide application. The residues will be extracted from soil samples and analyzed by GLC.

Effects of pesticides on non-target soil organisms. The investigation will be in the same plots in which persistence of pesticides in soil is assessed. Four 5 cm diameter x 15 cm deep soil cores will be taken from each plot on each sampling date, and the soil-inhabiting invertebrates extracted in Tullgren funnels then identified to orders, families and trophic groups.

Provision of training and upgrade of pesticide residue analytical capabilities in Jamaica. The University of West Indies residue laboratory currently has the capability to analyse for diazinon, malathion, chlorpyrifos, ethoprophos, profenos, deltamethrin, ?-cyhalothrin and permethrin. We plan to provide standards and upgrade their capabilities to cover all relevant halogenated pesticides and those containing a phosphorus group. Sources of funding to upgrade the analytical capabilities will be sought from industry and grant providing agencies. There is 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 residue analytical capabilities essential. There is a dearth of information on the persistence of pesticides in soil and on plants under tropical conditions. 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. We have accumulated data on residues from market basket surveys and sampling of export crops. The current study will eliminate the need for residue analyses of some pesticides that are relatively transient in soil and on foliage or fruit, and hence present little hazard to the consumer.

i. **Projected outputs:** Elimination of the need for analyzing residues of some pesticides. Identification of spraying harvest intervals for pesticides commonly used on hot peppers.

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

k. **Projected Start:** October 1998

l. **Projected Completion:** September 28, 2002

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

n. **Budget:** $ 9,020 – CARDI; $ 4,032 – 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:** Frank McDonald, Dionne Clarke-Harris, Vassel Stewart – CARDI.

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 Activity:** 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 continue to gather information 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 form 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 by the end of Year 8 a market study will be completed at U.S.A ports in Miami and New York.

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 Date of Completion:** September 28, 2002

m. **Projected Person-Months of scientist time per year:** 4

n. **Budget**: IPM CRSP: $ 7,645 - CARDI.

III.2 Social and Gender Issues affecting IPM Adoption

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. **Hypotheses:** Knowledge of 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 and future 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 utilising these technologies 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. **Progress to date:** No recent progress has been made.

h. **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.

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

l. **Projected date of completion:** September 28, 2002

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

n. **Budget:** IPM-CRSP: $ 3,188 – Virginia Tech, subcontracted to U. C. Davis.

IV. IPM Research Enhancement through Participatory Activities

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, Frank McDonald – CARDI; Weed Scientists at either Pennyslvania State University or Virginia Tech.

b. **Status:** New Activity

c. **Objectives:** To identify a candidate for an advance degree in weed science or management, and/or in information technology, related to integrated pest management.

d. **Hypothesis:** Education of an in-country person in these areas 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 pressure in the tropical areas of the Caribbean. Formal training in weed science and integrated weed management approaches is lacking.

g. **Relationship to other IPM-CRSP activities at the site:** Most IPM system have both a weed and an information component. During the candidate's studies, they valuable information will be added to help refine present IPM technologies.

h. **Progress to date:** No student has yet been identified in Jamaica; other CARDI locations are looking to find a candidate. Degree programs have been examined at both Penn State and Virginia Tech.

i. **Projected outputs:** (1) Completion of an advanced degree in weed science and/or in information technologies; (2) Knowledge gained to assist in capacity building.

j. **Projected impacts:** The student 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 date of completion:** September 28, 2004

m. **Projected Person-months of Scientist Time per Year:** 6 months

n. **Budget:** IPM-CRSP: $ 11,525 – Virginia Tech (or where student matriculates). Some carry-over funds from budgeted items in year 8.

IV.2. Integration of World-wide Web and GIS - for Real-time Monitoring, Communication, and Dissemination of Pest Management Information

a. **Scientists:** Frank McDonald, Dionne Clarke-Harris, Raymond Martin – 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 areas to reduce quarantine restrictions for export. Identify high pest areas for more rapid response 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 Activity:** 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 both the RADA server and on a CARDI server. A Penn State application will be implemented weekly, and this will 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 on a weekly basis. 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 output:** (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 Date of 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

(September 30, 2001 – September 29, 2002)

ACTIVITY	SCIENTISTS	YEAR 9 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; United States: S. Fleischer – Penn State Univ.	21,882	
I.2. IPM of Major Pests Affecting Sweetpotato in the Caribbean	Jamaica: K. Dalip – CARDI; D. McGlashan – MINAG; St Kitts: L. McComie – CARDI; United States: J. Bohac, D. M. Jackson – USDA; C. Edwards, Ohio State	26,070	
I.3. Assessment of Virus Incidence in Superior Caribbean Sweetpotato Varieties	Jamaica: K. Dalip – CARDI; United States: D. M. Jackson – USDA; S. Tolin, Virginia Tech		5,000[b]
I.4 Integrated Pest Management (IPM) Strategies for Reducing Impact of Tobacco Etch Virus and Broad Mite on Hot Peppers	Jamaica: F. McDonald, D. Clarke-Harris, K. Dalip, R. Martin – CARDI; J. Goldsmith, D. McGlashan, M. Williams – MINAG; P. Chung – RADA; W. McLaughlin – UWI; United States: C. Edwards, M. Schroeder – Ohio State; S. Tolin – Virginia Tech	40,991	5,000[b]
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; United States: S. Tolin – Virginia Tech; S. Fleischer – Pennsylvania State		23,800*

	Univ.; D. M. Jackson – USDA.		
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, F. McDonald,– CARDI; D. Robinson – UWI; United States: C. Edwards – Ohio State	13,052	
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: F. McDonald, D. Clarke-Harris – CARDI; Trinidad: V. Stewart – CARDI	7,645	
III.2. Social and Gender Issues Affecting IPM Adoption	Jamaica: D. Clarke-Harris – CARDI; United States: C. Harris – Virginia Tech; J. Momson – U.C. Davis	3,188	
IV. IPM ENHANCEMENT THROUGH INFORMATION TECHNOLOGIES			
IV.1. Research Enhancement through Training	Jamaica: student to be selected United States: PSU or VT	11,525	
IV.2. Integration of World-Wide Web and GIS for Real-Time Monitoring, Communication, and Dissemination of Pest Management Information	Jamaica: F. McDonald, D. Clarke-Harris, R. Martin – CARDI; P. Chung, RADA; United States: S. Fleischer, B. Miller, Penn State Univ., L. Grossman, S. Tolin, VA Tech;		17,318*

Carry-Over from Previous Years of IPM-CRSP Funding
* US-AID Mission and Technical Assistance for Gall Midge Complex
[b] Biotechnology funding

Ninth Year Work Plan for the West African Site in Mali

In IPM CRSP Year 9, the fourth year of Phase II, the Mali site will continue its primary focus on periurban export horticulture, with a secondary focus on innovative research for control of *Striga, a* parasitic weed on basic food crops. Three crops are 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 second stage testing integrated packages for green bean and hibiscus, with first stage research on tomatoes still advancing. Innovative research on seed dressing with herbicides for control of *Striga* on basic food crop cereals millet and sorghum, begun in 1999, is continuing. Research on the best modes of technology transfer have been introduced into Farmer Field Schools in the targeted villages and are having substantial impact on beneficiaries.

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 two master's 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 small-scale producers, including women's horticulture and export markets; *Montana State University*, contributing expertise in post-harvest assessment, 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. A Ph.D. graduate student will have started in fall 2001 in vegetable entomology at *Purdue University* and another two are scheduled to begin during the year: an American in entomology at *Montana State University* and another at *North Carolina A & T*.

Summary of Ninth 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	$16,232
4	Integrated Package	Gamby, Théra, Diakité, IER; Foster, Purdue			X	X	X	$9,935
II. IPM in Hibiscus								
1	Insect Components		X	X	X			
2	Weed Components	N'diaye, IER; Westwood, VT			X	X	X	$3,052
3	Integrated Package	Gamby, Noussourou, Dembélé, IER; Foster, Purdue; Westwood, VT				X	X	$18,225
III. IPM in Tomatoes								
1	Disease Components	Diakité, Théra, IER; Gilbertson, UC-Davis		X	X	X	X	$19,263
2	Insect Components	Gamby, IER; Foster, Purdue		X	X	X		$1,788
3	Weed Components	N'Diaye, IER; Westwood, VT		X	X	X	X	$5,610
4	Integrated Package	Gamby, Théra, N'Diaye, IER; Foster, Purdue; Dunkel, MSU			X	X	X	$36,052
IV. Farmer Field School								
1	Dissemination of IPM Packages	Gamby, Théra, N'Diaye, IER; Foster, Purdue; Dunkel, MSU				X	X	$12,331
V. Socio-Economic Analyses								
1	Gender Inventory	Sissoko, IER; Yeboah, NCAT; Moore, VT			X	X	X	$2,392
2	Promotion of Pest Management Practices	Sissoko, Sow, IER; Harris, Moore, VT; Yeboah, NCAT				X	X	$10,176
3	Strengthening Stakeholder Relations	Gamby, IER; Moore, VT			X	X	X	$10,798
4	Partial Budget Analyses	Yeboah, NCAT; Sow, IER		X	X	X	X	$33,620
VI. Developing a Quality Assurance System								
1	Technical Support to EQL and PSE	Traoré, EQL; Cobb, Hipkins, Mullins, VT	X	X	X	X	X	$125,491
2	Linkages with IPM Field Research	Traoré, EQL; Gamby, IER; Dunkel, MSU; Mullins, V T			X	X	X	$5,460
VII. Striga Management								
1	Innovative Techniques for Striga Management	Dembélé, IER; Westwood, VT	X	X	X	X	X	$19,945

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; (2) To begin integrating weed control methods into a comprehensive green bean production program; (3) To begin extending improved practices to growers.

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.

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. Experiments will test efficacy of the herbicides alachlor and bentazon in conjunction with current weed control practices. As the value of integrated practices is realized, these techniques will be incorporated into the curriculum of the Farmer Field Schools.

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 and initial studies of potential herbicides have been completed.

i. **Projected Outputs**: High yield of green beans, with reduced labor expenditure through the efficient control of weed species in vegetable production systems.

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 2002

m. **Projected Person-Months of Scientists Time per Year**: 2-3 person months.

n. **Budget**: IER/Sotuba, $7,040; University of Mali, $$9,000; Virginia Tech, $192.

I.4 Development of an Integrated Package for Management of Disease, Insect and Weed Pests on Green Beans

a. **Scientists**: *Subactivity leaders*: Kadiatou Touré Gamby; IER, Rick Foster, Purdue, Aissata Traoré Théra, Mariam Diarra Diakité, IER; Collaborating *scientists*: Florence Dunkel, Montana State University, Moussa Ndaiye, Bourema Dembélé, H.Traoré Siss oko, IER; Jim Westwood, Virginia Tech, Anthony Yeboah - North Carolina A & T; John Caldwell - JIRCAS.

b. **Status**: Continuing activity.

c. **Objectives**: To evaluate the combined use of the best IPM strategies for management of insect and disease pests of green beans identified in component studies during year 6 through 8. Methods used to manage diseases will include solarization with black plastic mulch, use of compost inoculated with a biocontrol fungus, and reduced watering schedules. Methods used to manage insects will include yellow and red plastic traps coated with vaseline and timely applications of neem.

Objective for the coming year: To evaluate the effect of IPM technology practices in comparison with farmer practices.

d. **Hypotheses**: The use of various management strategies for disease and insect pests of green beans has proven successful when conducted independently. This study will test the value of the combined use of strategies for both pest groups. The hypothesis is that the combined use of pest management strategies for disease and insect pests of green beans will result in higher yields, reduced disease and insect damage, reduced pesticide use and residues, and greater returns for the growers.

e. **Description of research activities**: Two treatments will be compared on five farms at each of six villages (Sanambele, Koren, Dafara, Dienfing, Kondialan, and Dialokaroba) arranged in a complete block design with five replications. (1) Grower standard – The grower standard will include the standard tw o waterings per day, well decomposed compost, possibly use of mineral fertilizers, and several applications of Decis for insect control. (2) IPM treatments – (a) preparation of soil with burned straw; (b) incorporation of well-decomposed manure; (c) water applied to plots once per day rather than twice; (d) blue vaseline covered traps placed out at crop emergence, yellow traps placed out at flowering; and (e) up to four applications of neem if necessary during vegetative growth, at the flower bud stage, and during flowering and pod formation.

The methods used for preparation of the compost will be the same as described previously. Plants will be watered on a need basis as reflected by the "balling" technique. Yellow or blue plastic traps (750 cm^2 area) covered with a 1:1 mixture of solid and liquid vaseline will be placed in the center of rows. Traps will be replaced weekly. Numbers of thrips or whiteflies will be counted weekly at seedling and flowering stages on the traps. Ratings of damage will be ma de after Decis and neem application. Beans will be harvested, graded according to market standards, and yields taken by grade. Farms will be used as blocks in a complete block design for the trials in the villages.

f. **Justification**: Component research for the disease and insect management strategies has shown promise for reducing pesticide use and pest damage in year 6, 7 and 8 studies. The next logical step in the process was to combine all the proposed IPM strategies into a single study, just as an IPM far mer would. The integrated package was tested in year 8, with excellent results. The studies need to be repeated to insure that the results will be similar under variable conditions over several years. This will allow us to evaluate the economic viability a nd practicality of the proposed IPM methods.

g. **Relationship to Other CRSP Activities at Site**: This activity is the result of previous and ongoing studies of components included in this study. Results of biological analysis will be used as data for socio-economic evaluation of treatments.

h. **Progress to date**: These studies were conducted during year 8. Data analysis shows that the yields and returns to growers are 30-40 percent greater in the IPM plots than in the farmers' practices plots.

i. **Projected Outputs**: Based on initial findings, we expect that growers can adopt this system of IPM techniques as a package that will result in greater yields, higher quality, less pesticide use, and greater returns for the growers.

j. **Projected Impacts**: Higher yields, lower pesticide costs and residues, reduced pest losses, more stable supply, and improved exportability of green beans.

k. **Start:** September 1998

l. **Projected Completion**: September 2002

m. **Projected person-months of scientist time per year**: 4-5 person-months.

n. **Budget** IER/Sotuba, $3,575; OHVN, $720; Purdue, $5,640.

II. Periurban Export-Oriented Hibiscus Pest Management Research

II.2 Weed Control Strategies for Hibiscus 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 hibiscus production systems.

Objective(s) for coming year: (1) To test techniques such as herbicides and cultural practices for weed control in hibiscus; (2) to begin integrating these techniques with current insect and disease techniques in hibiscus production.

d. **Hypotheses**: Effective weed control in hibiscus can increase yields and reduce weed problems in rotational crops.

e. **Description of Research Activity**: Weed control techniques, including hand weeding, herbicides, and cultural approaches, will be tested for efficacy on problem weeds that have been identified in hibiscus production. Techniques that prove to be effective will start to be integrated into other pest control programs under development.

f. **Justification**: Weeds can cause significant yield reductions in crops, both through direct competition for resources, and through the harboring of pathogens or pathogen vectors.

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 hibiscus.

i. **Projected Outputs**: Improved yield of hibiscus through the control of weeds.

j. **Projected Impacts**: Improved weed control practices in hibiscus fields will increase yields, and hence grower revenue, through sale of produce. Achieving weed control with minimum labor and chemical input will keep costs down and maximize the profit from increased yield.

k. **Projected Start**: October 2000

l. **Projected Completion**: September 2002

m. **Projected Person-Months of Scientists Time per Year**: 2-3 person months.

n. **Budget**: IER/Sotuba, $2,870; 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**: New 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. 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.

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 effectiv eness. 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, resear ch 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**: New activity

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-$3,465; OHVN-$720; University of Mali, $9,000; Purdue, $5,040.

III. Periurban Export-Oriented Tomato Pest Management Research

III.1 Management of Whitefly-and Aphid-Transmitted Virus Diseases of Tomato

a. **Scientists**: *ubactivity leaders*: Mariam Diarra Diakité, Aissata Traoré Théra - IER; Bob Gilbertson, UC-Davis; *Collaborating scientists*: Kadiatou Touré Gamby, Haoua Traoré Sissoko - IER; Ousmane Youm, ICRISAT; R. Foster-Purdue; John S. Caldwell - JIRCAS; Anthony Yeboah - North Carolina A & T.

b. **Status:** Continuing Activity

c. **Objectives**: To specifically identify pathogens causing tomato yellow leaf curl and wilt diseases, and to evaluate methods to mana ge whiteflies and whitefly -transmitted viruses and reduce insecticide usage on tomato.

Objective for coming year: (1) Develop an understanding of the identity of the whitefly-transmitted geminivirus(es) causing tomato yellow leaf curl disease in Mali; (2) Evaluate a number of potential management strategies for whiteflies and whitefly-transmitted viruses in field experiments; and (3) Develop methods for identifying wilt disease pathogens, and survey for wilt diseases in various growing areas.

d. **Hypotheses:** (1) tomato production in Mali is routinely attacked by geminiviruses transmitted by whiteflies (*Bemisa tabaci*); (2) this pest complex can be economically managed by using reflective mulches, insecticides, and resistant host cultivars; and (3) that tomato wilt diseases in Mali are caused by at least two different pathogens (*Pseudomonas solanacearum* and *Pythium aphanidermatum*).

e. **Description of Research Activities**:

(1) Develop an understanding of the identity of the whitefly-transmitted geminivirus(es) causing tomato yellow leaf curl disease in Mali. The whitefly-transmitted virus(es) causing tomato diseases (i.e., tomato yellow leaf curl in the Baguineda and Bancoumana areas will be surveyed. The whitefly-transmitted viruses associatedwith these diseases will be characterized using biotechnological approaches including nucleic acid squash blot hybridization and PCR and DNA sequencing. Samples of tomatoes and other plants with yellow leaf curl virus symptoms collected from two sites outside of Bamako on June 5-6, 2001, as well as samples collected during a survey planned for Jan-Feb 2002 will be used in experiments to gain insight into the nature of the *Tomato yellow leaf curl virus* (TYLCV) in Mali. Represenatative samples will be squashed onto nylon membranes, and membranes used in hybridization experiments with DNA probes for (i) any whitefly-transmitted geminivirus or (ii) TYLCV (Mediterranean isolate). To further characterize the virus, a portion or portions of the viral DNA will be amplified by PCR and the amplified fragment(s) cloned. 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.

(2) Evaluate a number of potential management strategies for whiteflies and whitefly-transmitted viruses in field experiments. An initial field experiment using a split-split-plot arrangement of 6 treatments (a type of 2^3 arrangement comparing “with” and “without” technological alternatives at each of three design levels) will be conducted to evaluate promising management strategies: (a) Mainplots (design level 1) will compare wavelength-selective plastic mulch (either yellow or aluminized silver) vs. farmer practices (no mulch); (b) Sub-plots (design level 2) will compare application of locally-used insecticide (Decis) for whiteflies and aphids under local conditions vs. no insecticide; (c) Sub-sub-plots (design level 3) will compare a tomato cultivar with suitable TYLCV disease resistance (Gempride) vs. most popular tomato cultivar currently planted in the OHVN zone; (d) yellow sticky cards in the field plots that could be used to monitor the movement of whitefly populations over time and space. The trial will be compared on 6 farmers’ fields, 3 in Bancoumana and 3 in Baguineda, near Bamako, and farms treated as replications. Data collection will include weekly insect counts [leaf turns for whitefly (*Bemisa tabaci*) and alate and apterous aphid (*Aphis cracewora*) numbers] and visual

examination for incidence of virus symptoms, as well as fruit yield and quality data. Farms will be used as blocks in a randomized complete block design. During the dry season (Oct-March) when the incidence of TYLCV is reported to be at its highest, two field plots will be established to further 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) Develop methods for identifying wilt disease pathogens, and survey for wilt diseases in various growing areas. A survey of tomato production areas will be conducted during the rainy and dry seasons for wilt disease problems. 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 *Pseudomonas 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, and Asia. 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, $6,848; UC-Davis, $12,415.

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 several alternative management methods for insect pests of tomatoes with chemical control methods.

d. **Hypotheses**: The use of several alternative pest management strategies will provide protection of one or more insects that is comparable to the use of broad-spectrum insecticides.

e. **Description of research activities**: Five treatments will be compared in 5 farmers' fields in each of six villages and in 3 farmers'fields in each of two villages (Cinzana). Farms will be used as blocks in a complete block design:

(1) Control (no control measures)
(2) Mosquito netting to protect plants from whiteflies (from emergence to 3 weeks)
(3) Applications of soap as needed to control aphids
(4) Applications of neem as needed to control caterpillars
(5) Blue and yellow vaseline covered traps to control aphids, whiteflies and thrips

Counts will be made every 7 days of the numbers of aphids, whiteflies, and thrips caught in the traps. At harvest, yield of harvested fruit will b e determined. Percentage of fruit damaged by caterpillars will be determined.

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).

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 2001.

m. **Projected person-months of scientist time per year**: 3-4 person-months.

n. **Budget**: IER/Sotuba, $1,788.

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 test integrated techniques such as herbicides and cultural practices for weed control in tomatoes; (2) to begin integrating these techniques with current insect and dis ease techniques in tomato production.

d. **Hypotheses**: Effective weed control in hibiscus can increase yields and reduce weed problems in rotational crops.

e. **Description of Research Activity**: Hand weeding is an effective weed control strategy in the small plots typically used for tomato production in the Bamako area. However, certain persistent weeds such as *Cyperus rotundus* present a greater problem, and control could be improved with judicious use of herbicides or other control techniques such as mulches. Experiments will test the efficacy of supplementing hand weeding with applications of herbicides such as glyphosate or others depending on availability in Mali.

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**: Improved yield of tomato through the control of weeds.

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 herbicide input will keep costs down and maximize the profit from increased yield.

k. **Projected Start**: October 1999

l. **Projected Completion**: September 2002

m. **Projected Person-Months of Scientists Time per Year**: 2-3 person months

n. **Budget**: IER/Sotuba, $2,805; IER/Cinzana, $2,613; Virginia Tech, $192.

III.4 Development of an Integrated Package for Management of Diseases, Insects, and Weeds on Tomatoes

a. **Scientists:** *Subactivity leaders*: Kadiatou Touré Gamby, Aissata Traoré Théra, Mariam Diakité, IER; Florence Dunkel, Montana State University; Issa Sidibé, OHVN. *Collaborating Scientists*: Bourema Dembélé - IER; Keith M. Moore, Virginia Tech; Rick Foster, Purdue; Abdoulaye Camara, Action Femmes Développement (AFD); Anthony Yeboah, North Carolina A & T.

b. **Status:** Continuing Activity

c. **Objectives:** Technologies developed in the first 8 years of the IPMCRSP-Mali and others developed under the IER Fruit and Vegetable Program adapted as an integrated package for tomatoes will be evaluated and disseminated broadly among Malian farmers.

Objectives for Coming Year: Test the package that has been developed.

d. **Hypotheses to be tested.** Small scale farmers can realize significantly greater profits from reduction of loss in tomatoes / other garden crops due to insects / micro-organisms by using, in collaboration with scientists: a) pest monitoring, e.g. trapping; b) locally-produced pest suppression materials; c) identification of loss-causing pests and their economic loss thresholds; and d) appropriate evaluation.

e. **Description of Research Activity:** Two treatments will be compared: IPM treatment and Farmer Practices. (1) IPM Treatments: (a) In seedbed – (i) soil treatment with hot water for control of soil diseases; (ii) burned mulch (straw) mixed with soil for weed control; (iii) solarization for three weeks to control soil diseases; (iv) netting for whitefly and grasshopper control; (v) improved variety with disease resistance; (b) Transplanting – (i) application of organic matter (2 tons/hectare); (ii) seeding spacing (.5 cm between rows and .5 cm between plants); (iii) 4 neem extract app lications. (2) Farmer Practice: (a) In seedbed – (i) no soil treatment; (ii) no insect treatments; (iii) no netting; (iv) no improved varieties; (b) Transplanting – (i) mineral fertilizer (between rows .4 cm and between plants .4 cm); (ii) Furadan for soil insect control; (iii) four or five Decis treatments. Weekly measures of disease incidence and insect counts will be conducted. At harvesting, disease incidence, damage on fruits and yield will be measured.

f. **Justification (relation to IPM-CRSP objectives and priorities):** This activity promotes participatory approaches such as participatory testing of farmer -defined technology. It fits into the IPM CRSP's broader goals to promote and develop sustainable agricultural technologies and practices, stressing I PM and organic practices, and increase information on health and environmental issues related to pesticides for a wider audience of interested persons. It is important to note that one of the proposed techniques that farmers may choose is neem. Neem is considered in the USA and Europe an organic pest suppression method so the potential for export markets of products on which this products are used is excellent.

g. **Relation to other CRSP activities at the site**: This activity builds on eight years of research experience in IPM in Mali.

h. **Progress to date**: Use of IPM Package reduced losses by 25 percent.

i. **Projected Outputs:** Higher yields and improved tomato quality.

j. **Projected Impacts:** This project will result in greater profit for the Malian produc ers and safer products for Malian consumption. If these farmers later become involved in the export market of tomatoes, they will have gained some understanding of how to address the needs of a organic farming criteria. This project will also result in a n NGO that understands participatory testing of farmer -designed technologies and IPM concepts.

k. **Project Start:** October 1998

l. **Projected Completion:** September 2003

m. **Projected Person-Months of Scientists Time per Year:** 4 months

n. **Budget:** IER/Sotuba-$2,926; IER/Cinzana -$6,501; OHVN-$720; Montana State, $25,905.

IV.1 Dissemination of Green Bean and Tomato 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**: New 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 field test 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 with in 50 kilometers of Bamako. The FFS will involve seven villages (Banakoro, Koren, Sanambélé, Koren, Dafara, Dienfing, Kodialan, and Dialakoroba). Trainers will be IER and OHVN technicians. The trials for the TOT permit participants to have directed expe riences 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 inclu de 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.

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 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 show promise for the speedy dissemination and adoption of IPM technologies. Twenty-five farmers in these villages and 4 IER and OHVN technicians are now capable of assisting in FFS demonstrations.

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 AFD- $1,018.

V. Socio-Economic Analysis of IPM Practices in Horticultural Production

V.1 Gender Inventory of IPM Knowledge, Attitudes, and Practices in Horticulture

a. **Scientists**: *Subactivity leaders*: Haoua Traoré Sissoko-IER; Anthony Yeboah, North Carolina A&T; Keith M. Moore, Virginia Tech; *Collaborating scientists*: Kadiatou Touré Gamby, Moussa Noussourou, Mariam Diarra Diakité, Aissata Traoré Théra, Penda Sissoko Sow, IER; Mah Koné Diallo, OHVN; Rick Foster, Purdue; Florence Dunkel - Montana State University; John S. Caldwell - JIRCAS.

b. **Status**: Continuing

c. **Objectives**: (1) To determine and analyze the gender division of labor in production, IPM, marketing, and decision-making of horticultural crops; and (2) to inventory the knowledge, attitudes and practices of men and women horticultural producers (both those who collaborate in on-farm trials and training programs and those who do not) concerning IPM technologies and pesticides in particular.

Objectives for the coming year: Refine the analysis of differences in the knowledge, attitudes, and practices of collaborating and non-collaborating farmers, as well as gender based differences among not only green bean, but also hibiscus and tomato producers.

d. **Hypotheses**: Because they perform many field tasks and are concerned about potential hazards to their health and that of their children, women have a stronger interest in reducing pesticide use than men. Similar gender differences between green bean and hibiscus and tomato producers will be found.

e. **Description of research activities**: A survey has been conducted within targeted horticulture producing villages. These data have been entered into a SPSS data file for analysis and preparation of a paper. The first paper summarizing the findings for three villages of green bean producers has been completed. A more detailed research paper including hibiscus and tomato pro ducers will be developed.

f. **Justification**: The important role women play in the daily family has been well documented. In the OHVN zone of Mali, women are not only preoccupied with domestic chores, but are also engaged in day-to-day farm activities. In s ome families, they provide more than 60 percent of the family labor that goes into farming. It is therefore important to understand the role of women in the production and marketing of horticultural (cash) crops which tend to be very labor intensive. It i s also important to determine the level of knowledge, attitudes and practices concerning IPM among horticultural producers in order to identify opportunities for introducing improved methods and communicate them more effectively.

g. **Relationship to Other CRSP Activities at Site**: This study will help in the design of research trials for IPM technology development. Knowledge of the role played by women in the use of IPM technologies will lead to better screening of potential treatments.

h. **Progress to date**: The initial survey for men and women in green bean and tomato crops has been completed and data entered and is being analyzed. Data collection for hibiscus remains to be collected. Initial findings suggest that women are not more interested in reducin g pesticide use than men, and that women are less informed about IPM alternatives.

i. **Projected Outputs**: This research will provide basic information on the contribution of women to the production and marketing of horticultural crops and how gender influence s the adoption of IPM technologies.

j. **Projected Impacts**: Increased adoption and use of IPM technologies; increased production and marketing of horticultural crops by women.

k. **Start:** October 1999

l. **Projected Completion**: September 2003

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

n. **Budget**: IER/Sotuba, $2,200; Virginia Tech, $192

V.2 Promotion of Pest Management Practices by Female Farmers

a. **Scientists:** *Principal investigators*: Haoua Traoré Sissoko, Pende Sissoko Sow (**E**R) Colette Harris, Keith M. Moore (Virginia Tech), Anthony Yeboah (North Carolina A & T); *Collaborating scientists*: Mah Koné Diallo (OHVN)

b. **Status**: New Activity

c. **Objectives**: (1) To identify social and economic constraints related to the adoption of IPM practices at the household and intra-household levels 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 will be established for women in the project villages where men's farmer field schools already exist and for a women's market-garden association in Banankoro (2) 1-2 women will be trained to work in these schools. Additional gender training will be given to the present farmer field school agents and trainers.

f. **Justification:** Women in these parts of Mali have their own farming projects of green beans for market on which they use significant quantities of pesticides. The women make the decisions as to whether to use pesticides and purchase them themselves although in most cases their husbands actually apply the pesticides while their wives are also working in the fields. Women have indicated in a survey carried out during the eighth year of IPM implementation that they would like to use even more pesticides than they already do, believing that thus they will increase yields. Men do not usually explain the IPM techniques they are taught to their wives, therefore, the women continue to use pesticides even when their husbands are already using IPM techniques in their own production. Since it is difficult for women to be active in mixed-sex schools, for the first year at least it is proposed to have separate schools for men and women.

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**: Male farmer field schools already exist but the present activities are new for year 9.

i. **Projected outputs**: (1) Women farmers using IPM techniques. (2) 1-2 women trained as farmer field school trainers. (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 2002.

m. **Projected person-month of scientist time**:

n. **Budget**: IER/Sotuba, $2970; Virginia Tech, $5823; OHVN, $360; AFD, $1,023.

V.3 Strengthening Stakeholder Relations

a. **Scientists:** _Principal investigators_: Kadiatou Touré Gamby (IER), Issa Sidibé (OHVN) Keith M. Moore (Virginia Tech); _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); Anthony Yeboah, (North Carolina A & T); 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 an d services delivered.

Objective(s) for the coming year: To determine the perceptions of exporters and other stakeholders concerning the individual IPM package components for green beans, hibiscus and tomatoes and 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.

e. **Description of research activity**: U.S. and Malian researchers and their OHVN and EQL colleagues will establish contacts with green bean exporters working in the targeted villages in order to conduct discussions about how collaboration to improve the conditions for increased and profitable green bean exportation. A Workshop among these stakeholders will be held to develop a program of action.

f. **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.

g. **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 highlight new areas which may need to be developed for improved IPM in Malian horticultural production.

h. **Progress to date**: A Participatory Assessment conducted this past year 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. Greater communication concerning why payments are not made and how IPM practices can stabilize incomes is needed.

i. **Projected Outputs**: Improved dissemination of IPM technologies leading to more consistent quality and production levels in horticultural export crops.

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, $4,500; OHVN, $360; Virginia Tech, $5,938.

V.4 Partial Budget Analysis of IPM Packages

a. **Scientists**: *Subactivity leaders*: Anthony Yeboah, North Carolina A&T; Penda Sissoko Sow, IER; *Collaborating scientists*: Kadiatou Touré Gamby, Moussa Noussourou, Mariam Diarra Diakité, Aissata Traoré Théra, Haoua Traoré Sissoko - IER; Rick Foster, Purdue; Keith M. Moore, Virginia Tech; Florence Dunkel - Montana State University.

b. **Status**: Continuing Activity

c. **Objectives**: To determine the feasibility and profitability of the various treatments used in the trials with aid of making reco mmendations 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 "superi or" 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.

At this level, current prices will be utilized which will include taxes or subsidies. However, since another objective of the program is to increase export of the products, profitability and feasibility at the level of the national economy will have to be assessed. This will require the use of prevailing international prices net of any taxes and subsidies.

f. **Justification**: The bottom line for IPM CRSP research is to increase the living standard of producers. Technologies or combinations of technologies that lead to the highest yields may not necessarily contribute to improved welfare of the user. It is imperative that these technological packages are assessed in terms of the cost and benefits to the user in order to formulate appropriate recommendations for adoption.

g. **Relationship to Other CRSP Activities at Site**: Most of the technologies being developed need to be evaluated for sociological and economic feasibility. In activities I.4, II.3 and III.4, technologies are tested as a "package" rather than in subsets, necessitating more complex socio-economic evaluation.

h. **Progress to date**: Partial budgets have been developed for some of the trials.

i. **Projected Outputs**: Information about the profitability of each technology or package of technology, and its potential for adoption by targeted producers.

j. **Projected Impacts**: This analysis will help screen technologies for future trials and also help in assessing or developing intermediate impact indicators for the program.

k. **Start:** October 1998

l. **Projected Completion**: September 2003

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

n. **Budget**: IER/Sotuba, $2,750; North Carolina A & T, $30,870.

VI. Technical Support for the Environmental Quality Laboratory and Pesticide Safety Education for Farmers

a. **Scientists**: *Subactivity leaders:* Mme. Halima Traoré - EQL/LCV; Jean Cobb, Pat Hipkins, and Don Mullins, Virginia Tech; *Collaborating scientists:* Mme. Safiatou Dem, Mme. Habiba Maiga - EQL/LCV; Harold McNair - Virginia Tech.

b. **Status**: Continuing activity

c. **Objectives**: (1) to develop methods for extraction and quantification of pesticide residues in crops; (2) to identify and quantify the active ingredient in formulated pesticides used on Malian crops; (3) to establish links with chemical manufacturers and suppliers and technical service personnel in Europe or Africa; (4) to carry out collaborative methods development and validation at both the EQL and the Virginia Tech Pesticide Residue Laboratory (PRL); (5) to develop a pesticide safety education program for periurban horticultural crop producers.

Objectives for coming year: (1) to improve skills needed for the routine analysis of pesticides applied on horticultural crops in collaboration with IER; (2) to begin training on high performance liquid chromatography (HPLC); (3) to make preparations for training a Malian graduate student in environmental pesticide residue analysis; (4) to continue developing linkages between the EQL and other pesticide residue laboratories in West Africa; and (5) to continue planning, develop materials for, and begin to deliver a pesticide safety education program designed for Malian growers.

d. **Hypotheses**: (1) routine pesticide screening of horticultural research crops will develop the skills necessary for eventual screening of Malian crop exports; (2) training in high performance liquid chromatography (HPLC) will provide another analysis tool for confirmation of pesticide residues; (3) training a graduate student in the area of environmental chemistry will extend the capabilities of the EQL to provide useful information on pesticide residues in the environment; (4) developing better communication between laboratory chemical and equipment suppliers and with personnel in other West African laboratories with similar mandates will strengthen the self-sufficiency of the EQL; and (5) a pesticide safety education program will help to ensure that horticultural crops meet export standards while promoting personal and environmental safety.

e. **Description of research activities**:
(1) Residue analysis of green beans grown in IER IPM field trials will be continued this year, and will include testing for the pesticides fenitrothion and fenvalerate in addition to

deltamethrin. These research activities also need to be extended to include pesticide residue analysis of other horticultural crops such as hibiscus, mangos and tomatoes. This will assist the IER field agents and cooperators in assessing the impact of pest management decisions on the yield and quality of crops grown for export.

(2) Training on high performance liquid chromatography (HPLC) in the summer of 2001 will involve the Pesticide Residue Laboratory (PRL) and Chromatography Research Laboratory (CRL) at Virginia Tech. Two EQL personnel will spend three weeks at Virginia Tech during the summer of 2001 and training will be continued when Virginia Tech personnel return to Mali for two weeks during the winter of 2001-2002.

(3) During both training sessions, preparations will be made to assist a potential Masters Degree graduate student with preparations for English training in Mali, the TOEFL and GRE, and application to Virginia Tech in 2002. The Masters Degree will involve a project designed to study pesticide residues in soil and water from Mali. This will satisfy one of the original mandates of the EQL: to direct some of its activities towards environmental issues.

(4) We will continue to assist the EQL in establishing better supply linkages with laboratory equipment and chemical suppliers by reviewing costs, availability and shipping requirements with the EQL staff. We will also continue to encourage EQL personnel to make contacts with other West African laboratories with similar mandates, and assist them in this effort. Both of these activities will strengthen the self-sufficiency of the EQL.

(5) A series of pesticide safety lessons will be sent to IER for ‘field testing’ in farmer field school sessions held for tomato producers in 2001. A curriculum committee (IER, OHVN, and others) will review a pesticide safety ‘flip chart’ developed for pesticide workers in the U.S., with the aim of customizing it for use in Mali. Instruction in pesticide safety education materials and methods will be provided to a small group of IER trainers and OHVN agents in the winter of 2001-2002. Content and methods will be modified if/as necessary, based on feedback from tomato growers and IER and OHVN. In January 2003, OHVN and IER trainers will begin to train farmers and other applicators who apply pesticides to export crops on a wider scale.

A "train the trainer" model will be used to reach Malian horticultural crop producers through IER trainers, OHVN agents, and other cooperators. The ultimate goals are: to develop a comprehensive pesticide safety program for Malian horticultural crop producers, and to deliver pesticide safety training to growers and those who apply pesticides to horticultural crops (usually growers) along with IER IPM recommendations. To that end, we will explore the cost and feasibility of hiring a graphic artist and a translator (for French and Bamenan) in Mali. Having a basic set of printed, illustrated materials adapted for use in Mali will support IER trainers, and ensure that pesticide safety lessons are consistent and complete. In 2001-02, we plan to make contacts and obtain cost estimates to determine if this can be accomplished within budget. If not, other avenues of funding will be explored.

f. Justification: The Environmental Quality Laboratory (EQL) of the Central Veterinary Laboratory (CVL) has a comprehensive mandate, which includes pesticide residue analysis. Pesticide residue monitoring requires procedures for sampling and testing products. The most important component is skilled laboratory scientists and technicians, with training in the proper analytic techniques. In addition, the laboratory requires appropriate, properly maintained equipment and access to supplies to operate at optimum levels. The use of pesticides in horticultural production further necessitates training of farmers in the safe use and handling of pesticides. To develop a quality assurance plan for Malian horticultural crops for internal consumption and export, a combination of a functional laboratory and a pesticide safety education program are needed.

g. Relationship to Other CRSP Activities at Site: Routine screening for pesticide residues in horticultural crops will assist IER researchers in selecting IPM practices that improve the quality of crops destined for European markets. Development and delivery of a pesticide safety education program designed for the horticultural crop producers in Mali will promote personal and environmental safety, and encourage the adoption of IPM practices.

h. Progress to date: Training in laboratory techniques for pesticide residue analysis, use and maintenance of equipment and instrumentation, and assistance in evaluating sustainability issues (ex. personnel, laboratory space, and freight costs of obtaining supplies in Mali) continued at the EQL and VT. Instruction in pesticide safety education was provided to a group of IER and OHVN agents and scientist as a trial run. This and a 'needs assessment' involving farmers growing horticultural crops for export were well received, and produced positive feedback for a larger "train the trainer" package in 2002. A preliminary survey of pesticide availability, labeling and product purity was initiated in 2001. Information was obtained from pesticide vendors in Bamako and farmers in villages. As part of the survey of Bamako pesticide vendors, small quantities of some formulated pesticides were purchased. Subsamples of these formulated products were brought to the U. S., where the identity and purity could be analyzed at VT. Involvement in a Participatory Assessment (PA) of farmers producing export crops provided a comprehensive overview of current and past green bean growing practices. These insights are useful in designing both laboratory and pesticide safety education activities to improve the quality of Malian green bean exports. During the PA, water samples were collected from the village wells for pH and pesticide residue analysis at VT.

i. Projected outputs: (1) ability of the EQL to perform pesticide residue analysis using gas chromatography (GC) to identify fenitrothion and fenvalerate levels (in addition to deltamethrin) in green beans sampled by IER; (2) capability of the EQL to use high performance liquid chromatography (HPLC) in pesticide residue analysis; (3) groundwork laid for bringing a Malian residue chemist to VT to study environmental chemistry, (4) improved communication and linkages with suppliers and West African laboratories; and (5) pesticide safety education instruction (materials and methods) delivered to the first group of IER and OHVN trainers.

j. **Projected Impacts**: (1) front-end quality control of green beans exported from Mali to European markets; (2) consequent greater market willingness to accept Malian products; (3) increased income to Malian farmers; (4) assurance of safety for Malian domestic consumers; (5) broader training for EQL staff, (6) strategies for EQL access to and acquisition of laboratory supplies and (7) personal and environmental protection as a result of adoption of IPM techniques and best management practices for pesticides.

k. **Start:** January 1999

l. **Projected Completion**: June 2004

m. **Projected person-months of scientist time per year**: 36 person-months.

n. **Budget**: EQL/LCV = $34,171; Virginia Tech = $91,320.

VI.2 Linkages with IPM Field Research and Development of a Quality Assurance System

a. **Scientist(s):** *Subactivity leaders:* Mme. Halima Traoré - EQL/LCV; Kadiatou Touré Gamby, IER; Florence Dunkel, Montana State University; Don Mullins, Virginia Tech. *Collaborating Scientists*: Bouréma Dembélé, Aissata Traoré Théra, Mariam Diarra Diakité, IER; Issa Sidibé, OHVN; Jim Westwood, Keith M. Moore, Virginia Tech.

b. **Status:** Continuing.

c. **Overall Objective(s):** To examine effects of farmer and IPM pest management strategies on pesticide residue levels and to obtain baseline information for development of a Quality Assurance System (QAS) for selected Malian crops.

Objective for coming year: a) Complete manuscript on pesticide residues from IPM pest management strategies in fresh green beans for export; b) Update Standard Operating Procedures (SOPs) based on revised practices in Year 8; c) Explore broader pesticide residue issues related to horticultural exports.

d. **Hypotheses:** 1) Pesticide history and current farmer practices result occasionally in pesticide residues that exceed export tolerances; 2) IPM strategies for export green beans do not exceed allowable pesticide residue tolerances; 3) Continually updated SOPs result in efficient procedures and collection of publishable data.

e. **Description of Research Activity:** 1) complete manuscript and put in journal review. This will require verifying data, reviewing results, analyzing data, preparing data tables for publication, updating the literature review, and writing the additional parts (Traoré et al. in prep.); 2) Review all SOPs (Gamby et al. 2001) written previously. If the extern grant (USDA) is funded, these externs from VPI (working with Mullins) or from MSU (working with Dunkel) will also pa rticipate in this part of the project; 3) Explore broader pesticide residue issues. Determine if any horticultural crops are being rejected from export due to pesticide residues.

f. **Justification:** This activity will provide specific information on pesti cide residues given various IPM stragegies used in green bean export crops of small -scale Malian farmers. In the process, participatory approaches in developing sustainable agricultural technologies and practices, stressing IPM and organic practices will be promoted. This activity will also increase reliability of data from the sampling, subsampling, extraction, and chromatographic analysis procedures.

g. **Relationship to Other CRSP Activities in Mali:** This activity supports the development of IPM CRSP-generated strategies for export green beans and hibiscus, as well as the development of the Environmental Quality Laboratory and Pesticide Safety Education Program.

h. **Progress to Date:** Standard operating procedures (SOPs) were developed and implemented for field sampling, laboratory sub -sampling, sample storage, and pesticide residue extraction and analysis in Years 7 and 8. A logbook and labeling system was developed and instituted in Year 8. A low -solvent procedure for extraction was learned and a video record of all of these procedures produced. Information on pesticide residue limits for Europe was obtained. MSU provided parallel funding for student extern to assist with SOP development in year 7. In year 8, Dunkel wrote and submitted a grant for extramural (USDA) funding to support additional assistance (externships) for this research activity. The grant was written for externs with a chemistry/chemistry lab background who were students in D. Mullin's pesticide course or F. Dunkel's natural product toxicology course.

i. **Projected Outputs:** A peer-refereed manuscript; updated SOPs; and increased quality control of pesticide use in the horticultural export market.

j. **Projected Impacts:** The completion of the refereed manuscript will provide a recognized way to share results regionally regarding procedures to analyze residue analyses and regarding pesticide residues following IPM programs.

k. **Start:** October 2000

l. **Projected Completion:** September 2003

m. **Projected Person-Months of Scientists Time per Year:** 4 months.

n. **Budget:** Montana State, $5,460.

VII. Innovative Techniques for Striga Management

VII.1 Innovative Techniques for Striga Management

a. **Scientist(s)**: Subactivity leaders: Bouréma Dembélé, IER; Jim Westwood, Virginia Tech; Collaborating scientists: Mountaga Kayentao, 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 study mechanisms of *Striga* resistance in selected sorghum lines.

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.

e. **Description of Research Activity**: Research will build on previous work, begun during visits of Bouréma Dembélé to Virginia Tech (April, 1999) and Jim Westwood to Mali (July, 1999; July, 2000). This work on herbicide seed coating led to identification of five candidate herbicides with selectivity in sorghum and millet. Results from field tests indicated that 2,4-DB showed promise in reducing *Striga* emergence on sorghum. These results will be confirmed and additional research in Mali will refine methodologies and dosages to validate results and optimize protocols. Specific variables that will be examined include herbicide rate and crop variety, and parameters measured will include crop height, time to flowering, and yield, as well as number of *Striga* per host, time of *Striga* emergence and total *Striga* biomass accumulation. An important experiment will be to determine the length of time that the herbicide treatment is effective in preventing *Striga* growth, and will be studied in pot experiments and hydroponic bags. In addition to questions such as those suggested in relation to herbicide seed treatment, it will be possible to begin characterizing mechanisms of *Striga* resistance in locally selected sorghum lines. 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. Addition 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.

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*.

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, $5,390; University of Mali, $9,000; Virginia Tech, $5,555.

Ninth Year Work Plan for the Eastern Africa Site in Uganda

Year 9 IPM CRSP activities at the African Site in Uganda will focus on five topical areas. First, research activities will continue development of IPM packages for important legume (cowpea and groundnuts) and cereal crops (maize and sorghum) with transition farming systems in Eastern Uganda. Second, the development of IPM packages for two, high-value horticultural crops, tomato and potato, will continue. The development of pest management altern atives for both legume and horticultural crops is particularly important because the production of these crops is associated with excessive use of pesticides. Third, work begun in Year 7 on incidence of moulds and mycotoxins on maize and groundnuts will c ontinue. However, the focus of this particular activity will be oriented towards determining the effects of harvesting techniques and on-farm processing on disease incidence in order to develop appropriate post -harvest pest management options. Fourth, so cioeconomic assessment activities will focus on crops and technological packages that have not yet been evaluated and include a tomato marketing assessment and an adoption study of IPM packages for cowpea and groundnuts. Fifth, IPM informational outputs for the IPM CRSP Uganda Site will be further developed and disseminated. An IPM CRSP Symposium will be planned and held in Uganda during Year 9. The main purpose of this symposium is to foster enhanced regional IPM research collaboration. Finally, as an affiliated activity with funding from USAID/Kampala and the IPM CRSP Management Entity (ME), will examine the etiology, epidemiology and integrated management of coffee wilt (*Fusarium xylariodes* (telemorph=Gibberella xylarioides).

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 Organiz ation (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 facili tated 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 compl ete or initiate their 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 ef fort 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.1. High Commercial Value Legume Crops associated with High Pesticide Use

IPM CRSP activities in Uganda continue to focus on cowpea and groundnuts. These two crops are important food security crops in Eastern Uganda and they both contribute to farm incomes. Frequent and often excessive pesticide use is associated with the production of these two crops.

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. Okurut-Akol-NARO/SAARI; A. Agona, NARO/KARI; V. Odeke, DAO's Office, Kumi; E. Iceduna, DAO's Office, Pallisa; R.B Hammond and M. Erbaugh -Ohio State; Graduate student, Makerere University. **Collaborators**: Rockefeller Foundation (Forum) [cost sharing on M.Sc. student for local networking and scaling -out].

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

c. **Objective**: The overall objective is to reduce and rationalize pesticide usage on cowpea in Eastern Uganda. **Year 9 objectives** are: (1) scaling-up dissemination of IPM technologies; (2) refining IPM options by (a) integrating synthetic and biorational treatments to manage field pests and bruchids (b) validating EILs and action thresholds of flower thrips, aphids and pod borers to guide insecticide application on-farm; (3) broadening the germplasm base for cowpea improvement in terms of disease and insect pest resistance, good agronomic traits and post-harvest storage qualities; (4) integrating defoliation and minimum insecticide application for management of the major pests and diseases; (5) determining the effectiveness of predators and parasitoids of cowpea insect pests; (6) determining the effectiveness of parasitoids against cowpea bruchids (*Callosobruchus maculatus*); and (7) determining the efficacy of pheromone baited trapping on cowpea bruchids in the field.

d. **Hypotheses**: (1) An IPM strategy, involving close spacing, early planting and strategic insecticide application (one spray application each at budding, flowering and podding) will control cowpea pests, eliminate the need for calendar spraying by farmers, and will be adopted by farmers. (2) Integration of synthetics and biorationals are 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) Some cowpea germplasm from IITA and other local collections have superior resistance to cowpea pests and diseases than traditional cvs *Ebelat* and *Icirikukwai*. (5) There are predators and parasitoids that exert significant biological control pressure on some major insect pests of cowpea in Uganda. (6) Well-timed defoliation reduces incidence of insect pests and diseases of cowpea. (7) Damage of stored cowpea by bruchids is reduced by parasitoids. (8) Pheromone trapping will eliminate or reduce populations of cowpea bruchids.

e. **Description of Research Activity**: This activity is subdivided into nine sub-activities:

(1) Dissemination and adoption of IPM technologies.[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 8 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 and the farmer traditional practice of spraying 5 times, starting 10 days after emergence. With eac h farmer group a demonstration trial using a randomized block design with 2 replications will be established. Individual treatments will be 10 m. by 10m. Field monitoring of pests and diseases will be conducted with farmers every two weeks following seedling establishment. Data on pests and disease incidence and yields will be collected and discussed with farmers. Additionally, cost - benefit analysis will be carried out to determine the profitability of the IPM packages.

(2) Refining of IPM. [Adipala-Ekwamu; S. Kyamanywa; A. Agona; R.B. Hammond, G. Luther]. A second study will validate and incorporate economic injury levels (EIL) and action thresholds and, control of post-podding pests and bruchids using biorational products. Randomized block design trial s with 4 replications will be established at two locations in Kumi and Pallisa districts in eastern Uganda. Individual treatments will be 6 m. X 6 m. Treatments include the following: IPM 1, sole crop cowpea sprayed 3 times at budding, flowering and poddi ng; 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 budding; IPM 4, spray at budding, a second spray (synthetic) depending on EIL(for thrips) at flowering; and third spray with botanical at budding. Fields will be monitored through 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.

(3) Screening cowpea varieties (Cowpea germplasm). [E. Adipala, S. Kyamanywa, H. Warren] Screening of cowpea germplasm for diseases (particularly Cowpea scab (*Sphacelom* sp.), Cercospora leaf spots, white zonate leaf spot (*Dactuliophora tarri*), and false rust (*Synchytrium dolichi*) pest resistance (aphids (*Aphis craccivora*) and thrips (*Megalurothrips sjostedti*), and agronomic traits (bo th for leaf and grain production) will continue with new cowpea introductions from IITA, Nigeria. The materials will be evaluated at Kabanyolo (MUARIK) and SAARI. The best performing entries will be subjected to more intense disease and pest pressure before selecting <30 lines for multilocation trials, and testing for post -harvest qualities.

(4) Integration of defoliation and minimum insecticide application for management of the major insect pests and diseases of cowpea. [H. Okurut Akol, V. Odeke, E. Adipala, S. Kwamanywa, R.B. Hammond, M. Erbaugh and G. Luther]. This is a continuing activity. The traditional farmer practice of harvesting cowpea leaves will be emulated by picking the second open leaf from tips of monopodial branches at weekly intervals. At each sampling occasion, approximately 15% of the leaves will be removed. Two promising cowpea cultivars, Large White 1 and Brown F along with the local variety Ebelat will be subjected to the following treatments: (1) Defoliation until on -set of podding and no spray; (2) Defoliation until on -set of podding plus 3 applications of insecticides (spray each at budding, flowering and podding); (3) No defoliation and no spray application; (4) No defoliation and 3 applications of insecticides, one spray each at budding, flowering and podding.

(5) Determine effectiveness of predators and parasitoids of insect pests on cowpea. (S. Kyamanywa, G. Luther,). **(a) Predators.** The main predator species identified in the survey conducted in Years 7 and 8 will be tested for efficacy/effectiveness in reducing the population of the major cowpea pest species (*Megalurothrips sjostedti, Aphis craccivora, Maurca testulalis, Heliothis armigera*) in Uganda. Cage experiments will be set up in the field with various 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, hencefo rth 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. **(b) 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 and kept pesticide-free all season long. This field will be isolated from pesticide treated fields so that drift and runoff will not be a source of pesticide contamination. 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 unknowns that are abundant will be sent to a specialist for identification to species.

(6) Field management of post-podding pests and bruchids on cowpea using selected botanicals and synthetic insecticides. [A. Agona, S. Kyamanywa, E. Adipala, R. Hammond, G. Mbata]. Management of post *podding (Maruca sp., Clavigrara sp. and Melanagromyza chalcosoma*) and bruchids (*Callosobruchus sp*.) will involve: (a) the evaluation of botanicals at two dosage levels and as synergists; (b) two synthetic insecticides; and (c) the non-treatment application (control) on cowpeas. The treatments will include crude extracts of tobacco, tagetes and tephrosia at the recommended rate and twice the rates, combinations of tobacco + tagetes, tobacco + tephrosia, and tephrosia + tagetes, and Sumithion, Ambush CY, and the non -pesticide control. The treatments will be imposed at 50% podding stage and continue weekly for 4 – 5 weeks, until pod harvest stage. Pod damage by suckers and borers will be scored in the field and fly damage immediately after threshing and cleaning. Bruchid damage will be assessed over a 3 – month storage period. The evaluation will be conducted in six farmers' fields and storage-managed conditions in Kumi district.

(7) Field Management of Cowpea bruchids (*Callosubruchus sp***.) using parasitoids and pheromones.** [G. Mbata, A. Agona, S. Kyamanywa, R.B Hammond]. **(a) Use of parasitoids.** The parasitoids, *Anisopteromalus calandrae* and *Pteromalus cereallela* will be evaluated as control agents of cowpea bruchids in the field. Cowpea plots will be established in two sites (Kabanyolo and Kawanda). In each site two plots will be established at least 500 m apart. The parasitoids, from laboratory routine stock cultures, will be released at cowpea pod filling stage. A minimu m of five hundred parasitoids will be released every two weeks until cowpea is harvested. The emergence damage done to cowpeas by bruchids and number of parasitoid adults will be compared for the treated and control plots. **(b) Use of pheromone-baited traps.** Cowpea plots will be established in two locations at Kawanda and Kabanyolo. The plots will be separated by an uncultivated plot. 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 a *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 a cross 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 wit h 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 yields are seriously curtailed by a multitude of insect pests and the low yield potential of the local cultivars. Occasionally, diseases, especially yellow blister disease, also cause significant losses. The cowpea germplasm base in the country is narrow (5 -7 major cultivars) yet there are a number of improved genotypes with the International Institute of Tropica l Agriculture (IITA), Ibadan, Nigeria. 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 8 to determine economic injury levels (EIL) and action thresholds need to be continued in year 9 for confirmation of results at farm level. Likewise, studies on predators of cowpea insect pests need to be continued in year 9 and be integrated with IPM options. Local knowledge suggests that cowpea defoliation, attributable to human harvesting and consumption of leaves, reduces incidence of certain pests species including pod borer (*Maruca*) and certain pod sucking bugs, which results in higher grain yields. 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 un derstanding of their biology and ecology may help us to enhance biological control in the Ugandan cowpea agroecosystem.

g. **Relationship to other research activities at the site:** The research components in this activity focus on developing an integrated p est management program for cowpea an important commercial and food security crop in Eastern Uganda.

h. **Progress to Date:** (1) Two season's data have been collected on validation and adoption of IPM technologies, and will continue for one more season. However, the student is due for graduation in October 2001; (2) Two season's data have been collected on establishment of EILs for cowpea thrips and is on going for one more season. However, the student is due for graduation in October 2001; (3) 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 one additional season; (4) The botanical studies are at an advanced stage requiring validation. The student is due for graduation in October 2001.

i. **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.

j. **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.

k. **Started**: September 1998

l. **Project Completion**: September 2002

m. **Projected Person-Months of Scientist Time per Year**: 3 months

n. **Budget for 2001/2002**: $14,014-Makerere University; $3024-OSU; $2362-Virginia Tech; and Fort Valley University $8,450.

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, C. Busolo-Bulafu and G. Epieru-NARO/SAARI; V. Odeke-DAO's Office, Kumi; R.B. Hammond and M. Erbaugh -Ohio State; C. Omwega, -ICIPE. Graduate and Undergraduate Students -Makerere University

Collaborators: ICRISAT, providing germplasm.

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

c. **Objective:** The overall objective is to develop integrated disease and pest management strategies for groundnuts. **Year 9 objectives** are: (1) To validate and disseminate IPM packages; (2a) To survey parasitoids and predators of groundnut pests; (2b) 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; and (4) To conduct multi -

locational trials for promising groundnut genotypes against Groundnut rosette virus (GRV) and Cercospora leaf spot.

d. **Hypotheses:** (1) An IPM strategy, involving close spacing, early planting, 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; (2a) There exist predators and parasitoids of major insect pests on groundnut in Ugandan cropping systems; (2b) Different insecticides exert the same level of mortality on predators and parasitoids; (3) Leaf miners, thrips and foot rot reduce groundnut yields in Uganda; and (4) Identified rosette and leaf spot resistant lines may show susceptible reactions in different locations.

e. **Description of Research Activity**: This is an on going activity which is divided into 4 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.

(1) Validation and dissemination of IPM packages. [E. Adipala; S. Kyamanywa - Makerere University; H. Warren -Virginia Tech, USA; G. Epieru -NARO/SAARI; R. Hammond and M. Erbaugh -Ohio State; Graduate Student -Makerere University]. IPM packages developed for groundnut pests and diseases and evaluated in year 8 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.

(2) Impact of Predators and Parasitoids of Major Insect Pests on Groundnut. [E. Adipala; S. Kyamanywa, - Makerere University; G. Luther - Virginia Tech, USA; G. Epieru-NARO/SAARI; R. Hammond -Ohio State; Graduate Student -Makerere University]. **(a) Survey of Predators and Parasitoids.** The survey of predators and parasitoids initiated in Year 8 will continue for another year. The survey will be conducted in the districts of Iganga, Kumi and Pallisa. Once a month, ten farmers' groundnut fields will be sampled for predators and parasitoids of major groundnut insect pests (thrips, aphids and leaf miners). Samples will be taken from sole and intercropped groundnuts. Sweep net sampling, pitfall traps, and direct count methods will be used to sample the various groups of natural enemies. Sweep net samples will be bagged and brought back to the laboratory to identify predators that may be feeding on groundnut pests. Plants will also be observed visually to find arthropods that may not have been captured by the sweep net. Aphid nymphs and adults and leaf miner larvae will be brought back to the laboratory for rearing, to see if parasitoids emerge. Predators and parasitoids will be identified at least to the family level and unknown species will be sent for identification. **(b) Assessment of the effect of different insecticides on major parasitoids and predators.** 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 MUARIK and TVC at Kumi.

(3) Determination of economic injury levels and action threshold levels for leafminers, thrips and aphids. [Adipala; S. Kyamanywa - Makerere University; G. Epieru, R. Hammond; Graduate 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, insecticides applied t wice a week, applied 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, ap hid 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.

(4) Evaluation of groundnut germplasm for resistance to major pests and diseases [E. Adipala; Kyamanywa; H. Warren; R. Hammond] Groundnut germplasm from ICRISAT, Malawi that showed resistance to rosette and Cercospora leaf spots in the previous IPM CRSP activity (together with germplasm from ICRISAT, Mali that showed resistance to rosette in trials at Serere (SAARI) will be evaluated for res istance stability to the major pests and diseases of groundnut in various locations in Uganda. The trial will be established as a completely randomized block design with genotypes in single row plots. A susceptible cultivar, Erudurudu, will be grown in bet ween lines to promote a high aphid population. Cercospora, isolated and multiplied in the laboratory, will be sprayed on to the crops using a hand sprayer.

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 ground nut 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 biocontrol we need to know the natural enemies in the system. Sub-activity (2) is the first step in our efforts to utilize and maximize bio-control in the IPM system we are designing for groundnut in Uganda/ East Africa.

g. **Relationship to other research activities:** The research components in this activity focus on developing an integrated pest management program for groundnut that addresses major diseases and insect pests.

h. **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; 57 groundnut genotypes from ICRISAT have been screened for resistance to groundnut rosette virus and Cercospora leaf spot during two growing seasons; Efficacy of different pesticides in controlling major pests and diseases of groundnuts have been studied in two seasons; A survey of natural beneficial insects has been conducted during one growing season; One M.Sc. student has been trained.

i. **Project Output**: IPM packages for groundnut rosette and Cercospora leaf spots will be validated and disseminated to groundnut farmers. New sources of resistance to the major pests and diseases of groundnut will also be identified and recommended. Importance of other pests and diseases of groundnut will be documented and a control strategy developed. A list will be compiled of predators and parasitoids of major insect pests which are the most important in exerting natural control of groundnut pests. One under graduate student will be able to do his/her M Sc. Manuscripts and pamphlets are being prepared. A post harvest and socio-economic element will be included in our IPM package.

j. **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. (4) Broader groundnut germplasm base in Uganda.

k. **Started:** September 1998

l. **Project Completion:** September 2002

m. **Projected Person-Months of Scientist Time per Year:** 3 months

n. **Budget for 2001/2002:** $ 21,643- Makerere University; $2,235- Virginia Tech; $3,843 - OSU.

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** (Sections 1.2.1, 1.2.2, and 1.2.3 from the Year 8 Work Plan have been integrated in this section).

a. **Scientists:** G. Bigirwa, Twaha Kalule, and Ben Sekamatte NARO/NAARI; R.C. Pratt, P.E. Lipps and Ron Hammond, OARDC-OSU, S. Kyamanywa and E. Adipala, Makerere University. **Graduate Students:** R.G. Asea, Makerere University; 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 and new 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 and insect pests [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 *Chilo partellus* (stemborer)]. (2) Enhance activity of biological agents to control termites; (3) Educate and foster adoption of recommended integrated management techniques for the above -mentioned pests and diseases, by farmers. **Year 9 objectives** are: (1a) Utilization of molecular -marker assisted selection to enhance identification and selection of quantitative resistance loci conferring resistance to MSV, NLB and GLS; (1b) Improvement of inoculation and infestation protocols for *C. zeae-maydis* and MSV respectively; (2) Continue impact assessment study of *C. flavipes* and examine potential for release of a new stem -borer parasitoid (*Xanthopimpla stemmator*); (3) Integrate application of ant baits and intercropping maize with Desmodium sp (green and silver leaf) and cowpeas for termite control; (4) Develop and disseminate IPM "best practices" recommendations to farmers.

d. **Hypotheses:** (1a) Marker-assisted-selection increases selection efficiency for resistance; 1b) There are alternative inocul ation methods which are more efficient than the current inoculation and infestation techniques; (2) Release of *(Xanthopimpla stemmator*) will augment the impact of *C. flavipes* on the stem-borer populations on maize; (3)

Combining the application of ant bait s (fish/molasses) with maize -legume intercrops will reduce termite infestation levels more than using these practices individually; (4) Farmers' adoption of recommended integrated pest management "best practices" reduces pests and diseases.

e. Description of Research Activity:

(1) Improving multiple disease resistance in elite maize germplasm using marker assisted selection and improved disease inoculation techniques (a) *Cercospora zeae maydis* resistance. Experiments to determine the repeatability and utility of the hypodermic injection inoculation procedure are being conducted. The most effective protocol from these experiments will be used in the marker -based selection trial during the off-season in Ohio for conversion of susceptible genotypes to resistance. The same techniques will also be applied to selection of superior germplasm for the Eastern U.S. Corn Belt in the OSU maize breeding program. The marker assisted conversion program, using the developed inoculation procedures, will be carried out by a graduate student at OSU. **(b) *Maize streak virus* resistance.** The two known methods currently in use for infecting maize with MSV include: - (i) dispensing 2 -3 viruliferous anaesthetized leafhoppers into the whorls of seedlings growing in the field and (ii) Seed puncture inoculation technique. However, these methods have several shortfalls: high cost of air conditioners, humidifiers, generators, carbon dioxide cylinders, failure of leafhoppers to transmit the virus etc. The proposed new method to be evaluated entails introducing potted maize seedling in cages and allowing virulent leafhoppers to feed on them for 48 hours to transmit the virus. Data to be collected will include incidence, severity, anthesis-silking-interval (ASI), plant aspect and yield. **(c) *Exserohilum turcicum* resistance.** Northern leaf blight (NLB) and Gray Leaf Spot (GLS) remain the greatest threat to sustainable maize production. Previous studies have shown that highly GLS resistant materials may be highly NLB susceptible. In additi on, research has that partial resistance can be highly effective in controlling NLB, and QTLs have been reported in CIMMYT maize line CML 202. In this study the simple sequence repeat (SSR) markers in the same chromosomal regions indicated by earlier RFLP mapping, will be used to facilitate transfer of NLB resistance factors to susceptible elite in -breds.

(2) Parasitoid release for management of stemborer populations. Currently the impact *of C. flavipes* released in Eastern Uganda to control stem-borers on maize and sorghum is being monitored. Preliminary results show partial establishment and limited control of the stem borers. Studies will continue to determine the impact of this parasitoid on stem borer population and damage to the two crops. To study the impact of *C. flavipes,* on *Chilo partellus,* two approaches, (i) time specific measurements of mortality and (ii) placement of cohorts in the field, will be used. In addition the potential of *X. stemmator to control stem borers* will be investigated in collaboration with ICIPE.

(3) Controlling termite damage on maize by attracting predatory ants (*Lepisiota* sp.) using fish-based baits and combining predatory ants with maize-legume intercrops to control termites. The trial will be conducted at Namulong e Agricultural and Animal production Research Institute (NAARI) and at Ikulwe Agricultural Development Centre where termite infestation is known to be high. The treatments will include intercrops of maize/soyabean, maize/cowpeas, maize/Desmodium, and a sole crop of maize. In each intercrop, two rows of the respective legume crops will be planted between two rows of maize. Soyabean and cowpea plants will be spaced at 25 cm between rows and 12.5 cm between plants while *Desmodium* will be spaced at 25 cm between rows and 25 cm between plants. Maize will be planted at a spacing of 75 cm between rows and 50 cm between plants. The plots will measure 15 m x 20 m separated by 1.5 m alleys. In one half of each treatment plot fish powder (500 g plot), will be applied twice, at 4 weeks after planting (WAP) and then 9 WAP in shallow grooves made in the middle of each treatment plot. The experiment will thus be a split -plot design, with intercropping as the main plot factor while the fish bait as the sub -plot factor. The treatments will be replicated five times. Both destructive and non -destructive sampling methods will be used to assess termite damage to maize plants and nesting of predatory ants. For non - destructive sampling, forty plants randomly selected from within the middle ten rows of each plot were tagged with blue ribbon for assessment of termite damage throughout the season. Each tagged plant will be inspected for damage to stems, leaves and cobs at 14, 28, 42, 56, 70, 84 and 102 days after emergence. Termites of the genus *Microtermes* are known to damage the root systems of crops. On four occasions, ten plants will be destructively sampled from each sub -plot to determine if the two interventions affected the activity of root feeding termites. Presence or absence of termites attacking roots in the different treatments will be recorded four times per season, at seedling, silking, green cob and dry cob stages, approximately 28, 56, 90 and 105 days after maize emergence. 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. At crop maturity, maize yields will be determined.

(4) Creation of awareness and education. Previous work on gray leaf spot showed variation in disease severity, incidence and distribution. Factors responsible for GLS epidemic development were also established and some of these can be avoided if farmers are sensitized. These include continuous maize cropping, leaving infected stover in the field, using infected stover as mulch material in banana and coffee plantations intercropped with maize. It is being proposed that training sessions be held to sensitize farmers especially in areas where the disease poses a serious threat.

f. Justification: Maize streak virus, northern leaf blight (*Exserohilum turcicm*) and gray leaf spot (*Cercospora zeae-maydis*) are the three major maize diseases in Uganda. Considerable efforts are being made by the national research program 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 which 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.

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. Intercropping maize with either soybean on groundnut caused a significant (P<0.01) reduction in termite attack, reduced loss in grain yield of maize and increased the nesting of predatory ants in maize fields. Species of the genera *Myrmicaria* and *Lepisiota* were the dominant ant predators recorded. Overall, the results suggested that intercropping might form a component of an integrated management stra tegy for termites in smallholder. Earlier IPM CRSP and DFID/NARO work also indicated that powdered fish, attracted significantly larger number of predatory ants maize fields compared to molasses and bagasse and resulted in greater ant nesting near maize p lants. Unfortunately, the two studies were conducted separately and the potential for greater termite control when the two strategies are used in combination has not been investigated.

g. **Relationship to other activities:** 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 disease, 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.

h. **Progress to date:** Four methods of *Cercospora* inoculation have been investigated: (1) hypodermic injection, (2) conidia l suspension, (3) stem inoculation, and (4) agar plug inoculation and studies are continuing to refine the protocol. It was possible to infect greenhouse grown seedlings. Differential genotypic responses for lesion length and plant leaf area affected were detected. Differences in latent period among genotypes were consistent. Hypodermic injection was an effective inoculation method and was less laborious than other methods. Stover was found to play little role in causing development and spread of GLS in areas where there was background inoculum coming from surrounding maize fields. In two districts of study with contrasting GLS incidence, 5 farming components were noted to play a significant role in the diseases development: type of variety, practice to leave previous season's stover on the soil surface, continuous maize cropping, intercropping maize with banana when mulched with stover. Simple Sequence Repeat polymorphisms between the resistant and susceptible parents have been identified. Restrictio n Fragment Length Polymorphism Markers were obtained to complete genome coverage. Major resistance QTLs were identified. Host responses were consistent across U.S. and African tests, demonstrating their applicability in both areas. Most GLS resistant material derived from Vo613Y are NLB susceptible. Previous IPM CRSP work using fish-baits broadcasted or buried with a few dry stalks of maize have attracted large numbers of ants and have resulted in greater ant nestings near maize plants. Termite damage w as significantly reduced and maize yields increased by over 30% in plots with protein-based baits.

i. **Projected Outputs:** (1) resistance factors and their association with components of resistance identified; (2) SSR molecular markers for assisted trait se lection identified (3) improved inoculation and infestation techniques; (4) a strategy for termite management developed, and (5) farmers awareness of IPM increased.

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 identified; (5) use of pesticides for control of termites reduced, and (6) relationship among researchers, extensionists and farmers enhanced.

k. **Projected Start Date:** September 2001

l. **Project Completion:** September 2002

m. **Project Person-Month of scientist time per year:** 3 months

n. **Budget:** $10,010 NARO/Makerere University; $ 36,955 Ohio State University.

I.2.4 Development of novel options for *Striga* management for small holder sorghum farmers

a. **Scientists:** J. Oryokot, P. Esele and J.R.Olupot, SAARI/NARO; Herman Warren and Brhane Gebrekidan, Virginia Tech. **Collaborating Institution:** ICIPE.

b. **Status:** Continuing activity with new modification.

c. **Objectives:** (1) To identify 2,4-D and 2,4-DB herbicides tolerant sorghum genotypes and evaluate the efficacy of herbicide seed coating in *Striga* management. (2) To evaluate the effect of intercropping sorghum and silver leaf desmodium (*Desmodium uncinutum*) in the management of *Striga*. (3) To asses the effectiveness of *Fusarium oxysporum* on the control of *Striga*. (4) To develop an effective and rational crop rotation system for *Striga* management in eastern Uganda.

d. **Hypothesis:** (1) Seed coating sorghum seeds with 2,4-D and 2,4-DB herbicides reduces striga infestation in sorghum. (2) Inter -cropping sorghum and silver leaf desmodium affects *Striga* infestation in sorghum. (3) *Fusarium oxysporum* controls *Striga* infestation. (4) There are differences in *Striga* infestation under continuous sorghum cropping and the proposed crop rotation system. (5) There are differences in sorghum yields between different *Striga* management options.

e. **Description of research activity:**
(1) Screen 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. Data to be collected will include: *Striga* seed germination and emergence, *Striga* soil seed bank, crop growth parameters and crop yield. Statistical analysis will be carried out using Genstat statistical package.

(2) 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 groundnuts and *Celosia argentia*. 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.

(3) Effect of *Fusarium oxysporum* on *Striga*. *Fusarium oxysporum* will be evaluated for pathogenic activity on *Striga*. The *Fusarium* spp will be clearly identified and isolated to exclude species that cause wilts in cotton and other crops. Experiments will be conducted to determine if *Fusarium oxysporum* and herbicides are compatible in the same mixture. *Fusarium oxysporum* will be grown on petri plates, which will be treated with herbicides of different concentrations that will be evaluated for development of the fungus. Compatibility of the herbicides and the isolates will be determined by assaying the fungi. The effectiveness of *Fusarium oxysporum* on the control of *Striga* in the field will be evaluated.

(4) Effect of cotton/sorghum/cowpea rotation system on *Striga* infestation. Farmers' fields previously identified as *Striga* hot spots in Kumi district will be used for this study. Paired plots of $100m^2$ each will be marked, and two cropping regimes imposed; one to receive a cotton/sorghum/cowpea rotation treatment and the other continuously cropped with sorghum. The trial will be replicated five times. The cropping scheme will be as follows: (i) Cotton/sorghum/cowpea: 1st rains 1997 (cotton), 1st rains 1998 (sorghum), 2nd rains 1998 (cowpea), 1st rains 1999 (cotton), 1st rains 2000 (sorghum), 2nd rains 2000 (cowpea), 1st rains 2001 (sorghum), 2nd rains 2001 (cotton). (ii) Continuous sorghum cropping: under sorghum all seasons up to 2nd rains 2001. 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 count 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. The *Striga* seed in the sample will be separated from the soil and counted to determine the soil *Striga* seed bank. Soil and socio-economic analysis will be performed and the impact on *Striga* interpreted on that basis.

(5) Integration of seed coating, intercropping and fertilizer use in management of *Striga*. 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: (a) the integrated *Striga* management practice identified from an earlier study; (b) seed coating with herbicide and cultural practices and (c) intercropping seredo sorghum with silver leaf desmodium. 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 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 20 soil cores will be obtained from each field and combined to give a single sample. The *Striga* seed in the sample will be separated from the soil and counted to determine the soil *Striga* seed bank. Available soil nitrogen will also be determined. Rainfall data will be collected using portable rain gauges for interpretation of the data. Statistical analysis is 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 developed for *Striga* 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 prosulfuron and 2,4-D as a possible component for management of Striga. The most recent results from Mali indicate that 2,4-DB is the most promising herbicide for seed treatment. Both 2,4-D and 2,4-DB will be tried under Ugandan conditions. Elsewhere (ICIPE), *Desmodium* has been shown to reduce *Striga* infestation when inter-cropped with maize as well as reducing stalk borer infestation. These have not been evaluated on germplasm available in the country nor has *Desmodium* been evaluated in sorghum. In addition, a team of Canadian and Malian scientists demonstrated that *Fusarium oxysporum* is an effective natural enemy of *Striga*. This finding needs to be confirmed under Ugandan conditions.

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:** Development of novel management options for *Striga* management for Ugandan conditions.

i. **Projected impacts:** (1) High sorghum yield; (2) Depleted *Striga* seed bank; (3) 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* is being completed and will soon be written up as part of the student's Msc. Work. The crop rotation study will be entering the fifth season at the site and it is to be continued with co-funding from NARO/DFID.

k. **Start-date:** 1998

l. **Projected completion:** September 2002

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:** $4,862 – Makerere/NARO; $5223 – Virginia Tech.

II.1 **Development of IPM strategies for High Value Horticultural Crops.** Both tomatoes and potatoes are considered high value horticultural crops in Uganda. The production of both of these crops is limited by major disease and insect pests. As a result, the production of both of these crops is associated with heavy and frequent use of pesticides.

II.1.1 Development of IPM Technologies for Tomato Production in Central Uganda

a. **Scientists Names and Institutional Affiliations:** Akemo M.C., Kyamanywa S., Adipala Ekwamu, Kaay A., Magaambo M. J. S., Kagezi, E. Entomology Student-Makerere University; Greg Luther, H. Warren, Virginia Tech.; Ron Hammond, OSU, Valentine Kasenge – Makerere University; Olanya, M. -CIP.

b. **Status**: Continuing activity.

c. **Overall Objectives**: (1) To reduce the use of pesticides on tomatoes; (2) To monitor and determine threshold levels of priority pests on tomatoes; (3) To develop alternative interventions for controlling priority diseases and pests of tomatoes; (4) To assess the levels of pesticides residues on market tomatoes. **Year 9 objectives** are: (5) To determine the relationship between pesticide residue levels and shelf life of tomato fruits; (6) To reduce the use of agrochemicals by introducing the grafting techniques and the use of rootstocks resistant to soil borne diseases; (7) To train an entomologist to Masters of Science Level.

d. **Hypothesis**: Improved tomato varieties will reduce incidence and severity of bacterial wilt, early and late blight, and insect pests, compared to farmer's varieties. The frequency of pesticide application can be reduced without yield loss. The re are cultural and varietal practices that reduce the incidence and spread of diseases and insect pests on tomatoes. There are Dithane M 45 residues on tomatoes sold in Ugandan markets. Use of grafting and resistant rootstocks to soil borne diseases will increase tomato productivity.

e. Description of Research Activity (approach):

(1) Testing of tomato varieties, MT56, Redlander, and thirteen new bacterial wilt resistant lines from AVRDC. (Akemo M.C., H. Warren, M. Olanya). The trial will be conducted on-station at KARI. The treatments, which will include 13 new varieties and two local ones (MT56 and MT55), will be replicated four times. Weeds will be managed as recommended for tomato production. Data will be collected on diseases (*Phytophthora infestans, Ralstonia solanacearum*) and insect pests (*Thrips tabaci, Myzus persicae, Helicoverpa armigera, Bemisia tabaci*) incidence and severity at biweekly intervals. Data will be analyzed to determine most resistant varieties for local production.

(2) Evaluation of management practices on incidence of *Phytophthora* and insect pests on tomatoes. (Akemo M.C.**,** H. Warren, M. Olanya, R. Hammond). This is a continuing activity**.** The experiment will be carried out in a split plot design. Fungicide spray and no-fungicide spray treatments will be assigned to the main plots, while the management practices will be allotted to the sub-plots. These managemtn practices will be various combinations of trellising vs. staking, mulching vs. no -mulching, and various insect control tactics including yellow thrips traps, *Metarhizium anisopliae* (a bio-pesticide), and an agro-chemical pesticide. Clean weeding will serve as the control. The trial, with three replicates will be conducted at KARI. Data on incidence of tomato disease (particularly *Phytophthora infestans* and bacterial wilt) and insect pests (*T. tabaci, M. persicae, H. armigera, B. tabaci*) will be taken biweekly. In addition to the above on-going work, laboratory studies will be conducted to determine the effect of different pesticides on survival of thrips.

(3) Determination of dithiocabarmate fungicide residues in tomato fruits of Uganda. (Kaaya) This work shall be carried out in Nangabo and Busukuma Sub -counties, Mpigi district. Ten commercial tomato growing farm ers shall be selected, five from each subcounty, and from each farmer, one tomato sample shall be collected in each of the two growing seasons at the time of harvesting. Data on quantities of Dithane M 45 applied by each farmer before and after harvesting shall be recorded. Fruits from these farmers shall be followed up to the markets of Gayaza, Kasangati and Kalerwe where they are sold. Fruit samples of 1 kg each shall be collected from twelve retailers, four per market and one fruit sample from each retai ler in the two growing seasons. Fruit samples shall be analysed for Dithane residues in the Faculty of Science Analytical Laboratory, Makerere University.

(4) Determination of relationship between thrips population, damage, and tomato yield. (Kyamanywa, S., R. Hammond). This experiment will be laid out in a randomized complete block design using four different insecticide spray regimes as the treatments, with the regimes consisting of sprays being applied at different weekly intervals. The trial will be conducted at KARI and data will be collected on population density of thrips and yield of tomatoes. In addition, artificial infestation of caged tomato plants with different levels of thrips will be carried out. ANOVA and regression analysis will be used to examine and determine damage -yield relationships to use in calculating economic injury thresholds.

(5) An alternative approach to increase tomato productivity by reducing soil borne disease through grafting. (Magambo, M. J. S.). Seeds of local *Solanum* spp that are resistant to soil borne diseases will be collected and grown in seedbeds in screen house. The developed plantlets will subsequently be transplanted to the field and arranged in a randomized complete block design with replicates. Rootstock will be grafted with preferred local table varieties. Thereafter, assessments and data collection on tolerance/susceptibility to soil borne diseases, graft compatibility, general growth characteristics of grafted tomatoes, perennation, and acceptability of ripe tomato fruits will be made.

(6) 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. These findings have been confirmed with growers using participatory assessment techniques and farmer surveillance. Results of 1st and 2nd rains of 1999 indicated that thrips were the main insect pests that farmers were spraying against. Therefore developing and using thresholds, and studying the effect of different cultural methods on thrips populations will help reduce pesticide applications against this pest. Blight resistant varieties are justified on the basis that reduced frequency of fungicide applications are not effective with high rainfall. 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 and on-farm studies that have been examining alternative methods of controlling tomato diseases and pests.

h. **Progress to Date:** One year's surveillance of farmers' fields indicates that late blight (P*hytophthora infestans*) was the most important disease and flower thrips (*Thrips tabaci*) were the priority pest, rapidly building up large numbers when not controlled effectively, and not responding to applications of pesticides by farmers. On-farm, late blight was best controlled by two applications of Dithane M45 per weekduring heavy rains and one spray per week during dry spells. Thrips populations were also observed to be low in cover cropped tomato plots. Farmers liked tomato varieties MT56 and Redlander. Their source, AVRDC, has developed additional lines to be tested in Uganda in Year 9.

i. **Projected out-puts**: (1) Bacterial wilt resistant/tolerant tomato cultivars identified; (2) Alternative disease and insect pest management practices developed; (3) Economic thresholds for thrips 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) Capacity to handle horticultural entomology problems increased.

k. **Project start**: September 2000

l. **Project end**: August 2002

m. **Projected Person-months of Scientisits' Time per year**: 10 months

n. **Budget:** $17,702– Makerere / NARO; $ 5,418 (carry-over) – OSU.

II.1.2 Evaluation of Population BC_3 Potato Genotypes for Resistance to Late Blight and Agronomic Characteristics

a. **Scientists**: J.J. Hakiza, R.M. Kakuhenzire, and W.W. Wagoire, NARO; Adipala Ekwamu, Makerere University; Sophien Kamoun, OSU; H. Warren, Virginia Tech, Modesto Olanya & Ramzy El-Bedewy, International Potato Center (CIP-SSA); B. Lemaga, PRAPACE; S. Namanda and Mildred Ochwo Graduate Students. **Collaborator:** Rockefeller Foundation (Forum) [cost sharing on Late Blight Characterization].

b. **Status:** New activity

c. **Objectives:** (1) to evaluate BC_3 population developed by CIP for pathogen resistance in Uganda, (2) to test and select promising BC_3 varieties for resistance stability under various environmental conditions, and (3) Laboratory characterization of late blight fungus *Phytophthora infestans*.

d. **Hypotheses:** (1) Materials with broad resistance to late blight are available and less vulnerable to pathogen aggressiveness. (2) Field resistance is more reliable than vertical resistance in the integrated late blight management str ategies. (3) Fungicide application is effective to aggressive strains of the pathogen. (4) Only A1 (US-1) mating type isolates of *Phytophthora infestans* occur in Uganda, Kenya and South Africa, as opposed to the United States, which has more diverse biotyp es.

e. **Description Of Research Activity:**

(1) Population BC_3 materials, i.e. advanced clones with horizontal resistance to late blight, will be secured from CIP and planted in 4 row -plots with 3 replicates during 2001B and 2002A cropping seasons in Kalengyer e. Field assessment for resistance to late blight basing on the overall phenotypic expression of the host and resistance and tuber characteristics will be determined.

(2) This research will involve the use of the characterization of isolates collected from the potato growing areas of Uganda using the Amplified Fragment Length Polymorphism (AFLP) technique. The purpose is to use this discriminative technique to compare these isolates with known A1 and A2 types in order to determine the biotypes available with in Uganda. The findings of this study will have an implication on the future control strategies employed for late blight, especially with regard to metalaxyl containing fungicides currently in use.

f. Justification:

(1) Host resistance is still a vital inp ut in late blight management strategies. Throughout the last decade emphasis has been on the use of clean clones of population A that have low levels of horizontal resistance to late blight. However the existence of more aggressive strains of the pathogen necessitates the introduction of clones with diverse resistance to enhance the IPM protocols of late blight management. The International Potato Center (CIP) has developed the most advanced source of resistance free of r genes from population A which has h orizontal resistance to late blight and improved characters e.g. earliness and adaptability to a wide range of environments within shorter and intermediate latitudes. The nature of resistance being non race - specific would be more effective against all rac es of the pathogen and presumably stable and long lasting.

(2) With the migration of *Phytophthora infestans* from its center of origin in Central Mexico, the A2 mating type has been found in a number of continents. This migration also corresponded with the development of metalaxyl resistance in the pathogen. The fungus isolates from the United States, South America, Asia and some parts of Africa have been characterized, but so far no work has been done in Uganda. This is attributed to the lack of facilitie s for this kind of genetic analysis, the high costs associated with the process, and legislation concerning the transfer of isolates between borders.

g. Relation To Other Activities: Potato production is associated with the heavy use of pesticides particularly fungicides. This activity combines screening resistant cultivars and more timely and reduced fungicide applications into an integrated strategy. It is closely related to other research work being conducted on potato by CIP and PROPACE.

h. Progress to-date: Integrated late blight packages involving a combination of resistant cultivars and fungicide application under IPM CRSP funding have been developed by M Sc student. Six varieties i.e Kabale and Victoria (susceptible), Rutuku and Nakpot3 (Resistant), and 387121.4 and 388575.5 (Moderate resistant) varieties were subjected to weekly, fortnightly, three weekly and monitored spray regimes including a no spray control. Data on the costs of fungicide application for each spray regime were recorded and benefit cost ratio computed for each cultivar and spray regime. A combination of host resistance was significant in the control of late blight and the monitored sprays (2 sprays) were more economic than the high fungicide usage or weekly sprays (6 sprays) . All the genotypes used belong to population A and therefore there is need to explore the integration of population B materials with fungicide usage in the control of late blight.

i. Project Output: Identify genotypes with dual resistance that will be in corporated in the integrated disease management packages.

j. Project Impact: Develop more durable integrated disease management packages. Reduced usage of fungicides and environmental pollution. Increased yields and reduced disease levels in farm fields .

k. **Projected Start:** September 2001

l. **Projected Completion:** September 2002

m. **Projected Person-Months of Scientist Time per year:** 2 months.

n. **Total Budget:** $4002 – Makerere/NARO; $639 – Virginia Tech; $2500 – OSU; Rockefeller Forum - $3400.

III. Post-harvest Management of Moulds and Mycotoxins in Maize and Groundnuts

III.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

b. **Status:** Continuing activity

c. **Overall Objective:** To determine mould incidence and mycotoxin contamination of maize and groundnuts in relation to on -farm practices. **Year 9 Objectives** are**:** (1) to determine the effect of harvesting techniques on moulds and mycotoxins in maize; (2) to establish the relationship between on -farm processing techniques and mould incidence in maize; (3) to validate different postharvest pest management options on incidence of moulds and mycotoxins in m aize; and (4) to establish the effect of shelling and storage methods on moulds and mycotoxins.

d. **Hypotheses:** Maize left to dry in the field prior to harvesting has high mould incidence and mycotoxin contamination. Processing techniques used by farmers p romote mould infection and mycotoxin production. Some post-harvest pest management options recommended for use by farmers affect mould and mycotoxin contamination of maize. Shelling and storage methods of groundnuts affect mould and mycotoxin contaminati on of groundnuts.

e. **Research Activity:** Graduate training of a PhD student at Virginia Tech, cost shared with Makerere University Staff Development Program will be done. This will be a sandwich program in which the student will take course work at Virgini a Tech for one year and conducts research in Uganda. Makerere University will pay for research while IPM CRSP will maintain the student at Virginia Tech. Maize and groundnut samples will be collected from Iganga and Kumi districts respectively and will be sent to Virginia Tech for analysis by the student during the Summer Term in IPM CRSP Year 9. In Iganga, fifteen farmers that dry or stock maize in the field shall be selected from three sites, five per site and two samples shall be collected from each far mer. Maize shelled by prising, beating and shelling machines shall be sampled, two samples for each method of processing. Studies shall also be conducted using Neem leaf powder and oil that are recommended pest management options. Here, six maize samples shall be treated with recommended doses of Neem leaf powder and oil, three samples for each category with a control, replicated three times. For all the suggested activities, moulds and mycotoxins shall be analysed. Experiments shall be done on shelled groundnuts from farmers in Kumi which will be stored in Polypropylene and Polyethylene bags. Each experiment will be repeated with three replicates and a control. Mould isolation and mycotoxin analyses will be done at intervals of one, two and three months of storage.

f. **Justification:** During the Year 8 maize sampling exercise in Iganga, it was observed that some farmers dry or stock maize in the field for some time before harvesting. These practices often do not allow fast drying due to rewetting either from rain or moisture in the environment. Such practices are likely to promote mould infection and insect infestation thus mycotoxin contamination. Some farmers traditionally shell maize by prising, beating and use of simple machines. Some of these practices may cause damage thus creating avenues for mould infection and subsequent mycotoxin production and therefore need to be investigated. Use of botanicals especially Neem products have been studied and recommended for control of storage pests but not moulds and mycotoxins. Year 8 results show that groundnuts are properly dried and stored unshelled by farmers. However, those to be marketed are shelled before packaging in different types of bags. Chances are that once shelled, the nuts may pick up moisture and mould infection may be accelerated. Studies therefore need to be conducted to simulate market storage methods of produce.

g. **Relationship To Other IPM-CRSP Objectives:** The proposed study is related to the on-going work on moulds and mycotoxin incidence in maize and groundnuts and also to post-harvest studies related to storage and insect infestation.

h. **Progress To Date:** Moisture content levels of different groundnut varieties have been determined and results show that the nuts were properly dried. Moulds have been isolated from groundnut varieties and maize. *Aspergillus sp* were the most prevalent moulds followed by *Fusarium* and *Penicillium*. Erudurudu was found to be the most susceptible groundnut variety to mould infection. Insect damage levels on maize were found to be low. Maize in Iganga was found to be stored in different modes that included polypropylene, spreading on floor, jerry cans and veranda. Maize spread on the floor and that stored under the veranda had the highest moisture content and mould incidence.

i. **Projected Output:** Relevant information on factors that affect mould and mycotoxin contamination of maize and groundnuts shall be generated. This information is very important in designing appropriate technologies that farmers can use to control mould and mycotoxin contamination of produce.

j. **Projected Impacts:** Control of mould and mycotoxin contamination of maize and groundnuts in Uganda.

k. **Projected Start:** October 1, 2001.

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

m. **Projected Person - Months of Scientists Time per Year:** 3 months

n. **Budget:** $5891 – Makerere; $22,316 – Virginia Tech.

IV. Socioeconomic Assessment, Information Dissemination, and Regionalization

IV.1 Socioeconomic Assessment of IPM CRSP Technology Development Activities in Uganda

a. **Scientist(s) Names and Institutional Affiliations:** V. Kasenge, W. Ekere, J. Bonabana, B. Mugonla – Makerere University; V. Odeke – Extension Crop Protection Specialist; Daniel B. Taylor – Virginia Tech; J.M. Erbaugh – Ohio State; G. Turiho -- Makerere University.

b. **Status: New or Continuing Activity:** New and Continuing 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 individ ual production activity, farm, nation, and beyond as appropriate. 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. **Year 9 objectives** are: (1) to develop standardized field data collection sheets and train personnel in their use, (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 the economic implications of using botanical pesticides in contr olling storage pests in the field and post podding pests of cowpeas.

d. **Hypothesis:** Adoption of IPM CRSP technologies is inversely related to farmers' age. Adoption is positively 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: (1) Data Recording from Development. [V. Kasenge, W. Ekere, J.Bonabana, D. Taylor] Standardi zed recording forms to facilitate the collection of data on input use and yields will be developed prior to the start of year 9 activities. The scientists and their graduate students who are conducting the trials will be trained in their use, as will the extension agents working with the project. Following the completion of the field trials, partial budgets will be prepared for use in their evaluation. **(2) Factors affecting the adoption of IPM CRSP management packages.** [M. Erbaugh, J.

Bonabana, D. Taylor, V. Odecke] A survey will be conducted in Kumi District to assess factors influencing the 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. **(3) Cost effectiveness of field management of post podding pests and bruchids on cowpea using selected botanicals and synthetic insecticides.** [B. Mugonala] Partial budgets will be developed to assess the cost effectiveness of management practices for pest and disease control on cowpeas in the field, and their implications for post harvest storage will be assessed. **(4) Tomato Marketing.** [V. Kasenge] Information on tomato marketing will be gathered through personal interviews of vendors and consumers. Venders and consumers of both genders will be interviewed. Our desire is to understand the marketing chain from the producer to the final consumer. Of particular interest is the effect of visible pesticide residue on tomatoes. Some say it enhances their sales a s people think that they are perceived to be of higher quality with residue – others say that the residue decreases sales because consumers are concerned about the health impacts of pesticides. This information coupled with the production information gath ered as part of the continuing activity will provide both information for a basic economic assessment of IPM CRSP tomato research and for an evaluation of whether to conduct an assessment on the broader economic impacts IPM CRSP tomato research and/or whole farm mathematical programming analysis of tomato producers. Either approach will require intensive use of computer resources.

Continuing Activity: The economic evaluations of selected year 8 trials will be completed. **(1) Tomato production.** [V. Kasenge] The economics of tomato production in Wakiso District will be assessed in more detail than typical for partial budgeting. That is, complete production budgets for tomatoes will be developed. While collecting this information, researchers will also deve lop a qualitative understanding of the nature of these peri-urban tomato farmers, and their production systems. **(2) Potato late blight.** [G. Turiho] Partial budgeting will be used for an economic evaluation of management options for control of potato late blight. **(3) Sorghum *Striga* Control.** [W. Ekere] *Striga* control treatments on sorghum including the seed treatments will be assessed with partial budgeting. **(4) Control of *Cercospora leafspot* and Rosette virus on Groundnuts.** [J. Bonabana, D. Taylor] Once an additional year of production data is obtained, the preliminary economic analysis of groundnut interventions that is contained in the last annual report will be completed and submitted for publication.

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 po tential spillover effects. Given the complexity of factors influencing agricultural production, 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:** Interaction with essentially all 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.

h. **Progress to Date:** The economic evaluation of the post harvest storage interventions has been completed, and a manuscript has been submitted for publication. A preliminary economic assessment of IPM CRSP groundnut activities has been completed. An additional years yield data is needed to complete the analysis. Data collection has been partially completed for the economic assessment of sorghum and potato trials. Arrangements have been finalized with Dr. Akemo and Mr. Kagezi for a plot level survey of tomato producers at the farms of Mr. Kigozi, Mr. Sserunjongi and Mr. Kakande of Busukuma sub-county Wakiso district. Jackline Bonabana has developed a first draft of her M.S. thesis proposal. A prelim inary cost-benefit analysis of the impact of predatory ants on termite damage to maize fields was conducted. An Economic evaluation of post - harvest storage interventions was completed and a manuscript is submitted for publication.

i. **Projected Outputs:** (1) A journal article submitted to the *East African Journal of Rural Development* on the economics of mono versus intercropping maize is forthcoming; (2) An article has been submitted to *Makerere University Agricultural Research Bulletin* on the economics of post-harvest storage treatments on cowpeas and beans; (3) A paper containing a preliminary economic assessment of groundnut activities was completed. Additional data (1 year) is needed to complete analysis and the paper will be submitted to a journal. A paper on this work was presented at Makerere University's graduate student forum; (4) MSc Thesis at Virginia Tech on impact assessment (economic surplus approach) of Longe 1 and bean seed treatment is nearing completion (year 6 workplan); (5) Two Ugandans will receive MSc degrees -- one from Virginia Tech, and one from Makerere University; (6) Papers will be presented at professional meetings and submitted for publication as the opportunities arise.

j. **Projected Impacts:** The impact assessment work will p rovide 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:** Continuing Activity: October 29, 2000;
New Activity: October 29, 2001

l. **Projected Completion:** Continuing activity: December 31, 2001;
New activity: December 31, 2002

m. **Projected Person-Months of Scientists time per Year:** 12

n. **Budget:** $16198 – Makerere/NARO; $24,263 – Virginia Tech; $9072 – OSU.

IV.2 IPM Information Development and Technology Transfer

a. **Scientist(s) Names and Institutional Affiliations:** Paul Kibwika -Makerere University; Mark Erbaugh- Ohio State University; Dan Taylor -Virginia Tech; Edison Mwanje - Extension Iganga District; Valdo Odeke -Extension Kumi District; Samwiri Kyamanywa - Makerere University; Greg Luther -Virginia Tech Univ.

b. **Status:** New or Continuing Activity: Continuing Activity

c. **Overall Objective(s):** The overall objective is to develop and disseminate informational outputs for the IPM CRSP Uganda Site. Two sub-objectives support this main objective: (1) to develop 6 user-friendly fact sheets on IPM of cowpea, groundnuts, stalk borer management on maize and sorghum, striga management on sorghum, pesticide application/safety and maize streak and gray leaf spot identification; and (2) to develop an IPM training program manual for groundnut and cowpea for use by extension agents.

d. **Hypotheses:** More information and IPM farmer field training will increase adoption of IPM practices.

e. **Description of Research Activity:** (1) The development of fact sheets will be coordinated by Paul Kibwika, Lecturer, Department of Agricultural Extension Education, in conjunction with seniors in the department as their final year projects. A standard format will be developed, and IPM CRSP research results collected and packaged into user-friendly fact sheets. Draft fact sheets will be evaluated with groups of farmers from cooperating NGO groups; (2) The training manual for IPM training on cowpea and groundnut will be assembled by an IPM CRSP team consisting of co -pi's Ekwamu, Kyamanywa, Erbaugh, Kibwika and Luther, during the 2^{nd} season 2001, and field tested during the first growing season 2002, at 6 locations in Kumi, Pallisa and Iganga districts.

f. **Justification:** IPM is a knowledge and information intensive pest management strategy. This activity is designed to develop fact sheets for a non-technical audience in order to expand the impacts from IPM CRSP research. An IPM training manual can be used to broaden dissemination of research results, reach new audiences, and provide a useful foundation on which to construct future and alternative training program.

g. **Relationship to other CRSP Activities at the Site:** Technology transfer is a critical component of all research activities if research results are to have an impact at the farm - level. Fact sheet development is a component of IPM CRSP field research activities. Training manual develop is particularly relevant to cowpea and groundnut crop improvement programs, but is also relevant to other crops.

h. **Progress to Date:** Three fact sheets have been developed, however, the potential for expanded output in this area is great. An outline for the training manual has been developed and needs to be adapted, expanded, illustrated and evaluated for final product development.

i. **Projected Output(s):** Fact sheets, extension bulletins, training module developed and tested, and articles on IPM for the popular press.

j. **Projected Impacts:** Increased awareness of IPM and of the IPM CRSP among farmers, Ugandan agricultural support institutions, and donors.

k. **Projected Start:** September 2001

l. **Projected Completion:** September 2002

m. **Projected Person-Months of Scientists Time per Year:** 4 months

n. **Budget:** $4180 – Makerere/Extension; $1000 – OSU.

IV.3 Regional IPM CRSP Symposium

a. **Title of Research Activity:** Regional IPM CRSP Symposium

b. **Scientist(s) Names and Institutional Affiliations:** E. Sabiiti and S. Kyamanywa, Makerere University; George Bigirwa and Robert Ogwong, NARO; Charles Omwega, ICIPE; A. Ekwamu, Rockefeller Forum

c. **Status:** New or Continuing Activity: New

d. **Overall Objective:** The main objective of the symposium is to foster regional collaboration in the area of IPM. This will be done by assembling a multi-disciplinary and multi-national group of scientists to present research findings on the "Current Status of IPM in sub-Saharan Africa".

e. **Hypothesis:** N/A

f. **Description of Activity:** The IPM Research and Extension Symposium titled "Current Status of IPM in sub-Saharan Africa" will take place in Kampala, Uganda, on September 3, 2002. Makerere Univeristy, NARO, and the IPM CRSP will serve as the primary hosts for this gathering. The call for papers will go out on July 10, 2001.

g. **Justification:** An IPM symposium in Uganda is considered important at this junction in order to facilitate scientific synergism and promote regional collaboration. There are many key contributors to IPM in the region including the IPM CRSP, ICIPE, Rockefeller Forum, CIAT, IITA, CYMMYT, CIP as well as the regional NARS. Integrated Pest

Management is an increasingly important trend in agricultural research and development in sub-Saharan Africa and thus an opportunity to show-case IPM and research developments in IPM are both timely and important.

h. **Relationship To Other CRSP Activities At The Site:** Would provide a venue for presentation of research results.

i. **Progress To Date:** New activity

j. **Projected Output(s):** Proceedings, reports in popular press

k. **Projected Impacts:** Enhanced regional attention and awareness of IPM

l. **Projected Start:** October 2001

m. **Projected Completion:** September 2002

n. **Projected Person-Months of Scientists Time per Year:**

o. **Budget:** $13,750 – Makerere/NARO.

IV.4 Geographic Information Systems To Enhance IPM Collaborative Research in Uganda

a. **Scientist(s) Names and Institutional Affiliations**: L.S. Grossman (Virginia Tech); E.A. Roberts (Virginia Tech); J. Boyer (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 collaborating agricultural scientists in Uganda with the capability to use the tools of Geographic Information Systems (GIS). In a GIS, researchers can assemble, store, manipulate, and analyze data and display graphically the relationships among a wide range of variables. A GIS can include environmental, agricultural, economic, and socio-cultural variables. Not only is GIS a useful tool for analysis, but it also assists in the formulation of hypotheses about relationships relevant to pest management.

A key dimension in a GIS is using researchers' powers of visualization to reveal relationships among variables that might not be evident when using other tools of analysis. Most importantly, use of GIS encourages scientists to explore the significance of **spatial** relations--that is, where agricultural features are located; their locations in relation to other environmental, land use, and socio-cultural features; distance relations among variables; and changes in locational patterns over time.

The techniques of GIS can be adapted to examine data at a variety of scales --national, regional, and local. Thus, GIS can be employed in varying contexts, from understanding the factors contributing to pest outbreaks over an entire country to analyzing the impacts of different crop combinations or resistant varieties in fields in a particular village in relation to IPM techniques.

The objective is to conduct a three-day workshop in Uganda with approximately fifteen participants. The workshop will begin on a Tuesday and end on a Thursday. Each participating scientist in the workshop will have access to a computer during the workshop. Participants will learn how to use the GIS software program ArcView, the most widely used GIS desktop program in the world. They will learn how to incorporate into GIS their own data that they have collected in the field. They will also learn how to analyze their data in relation to other environmental, agricultural, and socio-economic data available in GIS format in Uganda. The workshop will thus be useful for entomologists, agronomists, plant pathologists, agricultural economists, foresters, and others interested in land use and IPM.

Another dimension of the workshop is to provide instruction on how to use GIS to store information in a database. The database can be used to analyze both current patterns and changes over time. The GIS database can serve as a structured archive that can be explored as new questions and hypotheses are generated in the years to come.

Participants will learn how to interpret, create, and print computer-generated maps for their reports. Such use of GIS will enhance participants' abilities to develop hypotheses, analyze data, and publish the results of their research.

Because of the importance of spatial relations in GIS, it is essential to be able to record accurately the precise locations of data collection sites in the field and enter such coordinates into a GIS. Thus, participants will also learn how to use Global Positioning Systems (GPS) units in field exercises.

In preparation for the workshop, L. Grossman of Virginia Tech has collated existing GIS databases available in Uganda (on such features as soils, slopes, rainfall, rivers, roads, villages, land use, population densities and distributions, and socio-economic patterns). He will distribute the data to the Uganda team at the workshop in the form of a CD-ROM to serve as the foundation for their GIS. The Virginia Tech team will also prepare a written manual and on-line tutorial to assist participants in learning to use GIS.

d. **Hypotheses:** (1) Research productivity will be enhanced through the use of Geographical Information Systems and Global Positioning System technologies. (2) Developing the ability to think spatially is crucial for understanding the factors affecting IPM. (3) Increasing the ability to visualize spatial relationships among variables is crucial to research and implementation in IPM. (4) The factors affecting the spread and control of pest problems are a function of the interrelations among environmental, agricultural, and socio-economic patterns that can be analyzed through using GIS.

e. **Description of Research Activity:** No research. Workshop presentation.

f. **Justification (relation to IPM-CRSP objectives and priorities):** This project will facilitate technology transfer and improve infrastructure. It will also enhance the ability of scientists to communicate the results of their research and to improve the quality of their published results in peer -reviewed literature. It will provide tools to help evaluate pest management techniques. Use of GIS will assist in analyzing the complex relationships among the environmental, agronomic, and socio -economic variables that affect pest management.

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:** During March 2001, Lawrence Grossman of Virginia Tech visited Uganda. With the assistance of Dr. Kyamanywa, he contacted numerous individuals who could benefit from the workshop to discuss their interests and needs, collected digital data on Uganda for use in the GIS workshop, and established the venue for the future GIS workshop. He obtained maps of the research areas in Iganga and Kumi to distribute to potential participants to help them record the locations of their field sites so that such information can subsequently be entered into a GIS at the workshop. He also provided suggested frameworks for recording field data to enable their use in GIS.

i. **Projected Outputs:** Creation of training materials and databases for GIS implementation. Project scientists will be able to use GIS and GPS techniques to record and analyze their data and produce reports on their research. They will gain an effective means to manage data over time by using the database elements of GIS.

j. **Projected Impacts:** 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, 2001

l. **Projected Completion:** September 30, 2002

m. **Projected Person-Months of Scientists Time per Year:** 2 months

n. **Budget:** $13,438 – Virginia Tech; $4,565 – Makerere University.

V. IPM CRSP Uganda Site Emergency Response Work Plan - Coffee Wilt

Etiology, Epidemiology and Integrated Management of Coffee Wilt *(Fusarium xylarioides* (teleomorph = Gibberella xylarioides)

by

Dr. Ira Deep, 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

November 20, 2000

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 (a) soil borne (b) seed borne (c) produced on infected stems, leaves, husks (d) 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 in fected 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 determin e 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 co llected 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 long er 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 wi th 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 a nd 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 a nd 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: a) the point of infection; b) invasion of host tissue following penetration; and c) the relationship of age of tissue to infection.

c. **Hypothesis:** During development of coffee wilt disease, a) points of infection include roots, stems and/or leaves; b) the fungus moves into different tissues in the plant; c) 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 (1.3×10^6) of *Fusarium xylarioides*. Five cuttings of each genotype will be sprayed with inoculum and placed in a moisture c hamber 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 de grees 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, affe ct 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, 2001 – September 30, 2002)

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, H. Warren – VA Tech.; J. Mbata – FVSU; R.B Hammond, M. Erbaugh – OSU.	Makerere $ 14,014 OSU $ 3,024 VA Tech $ 2,362 FVSU $ 8,450
I.1.2	Integrated Management of Groundnut Insect Pests and Diseases	E. Adipala, S. Kyamanywa – Makerere; G. Luther, H. Warren – VA Tech; A. Agona – NARO/KARI; C. Busolo-Bulafu, Kumi; R.B. Hammond, M. Erbaugh – OSU.	Makerere $ 21,643 OSU $ 3,843 VA Tech $ 2,235
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 – NARO/NAARI; R.C. Pratt, R. Hammond – OARDC, OSU; E. Adipala – Makerere.	Makerere $ 10,010 OSU $ 36,955
I.2.4	Development of novel options for *Striga* management for small holder sorghum farmers	J. Oryokot, P. Esele, J.R. Olupot – SAARI/NARO; H. Warren, B. Gebrekidan – VA Tech.	Makerere $ 4,862 OSU $ 5,223
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 – OSU; V. Kasenge – Makerere; M. Olanya – CIP.	Makerere $ 17,702 OSU $ 5,418
II.1.2	Evaluation of Population BC_3 Potato Genotypes for Resistance to Late Blight and Agronomic Characteristics	J.J. Hakiza – NARO; A. Ekwamu – Makerere; S. Kamoun – OSU; H. Warren – VA Tech; M. Olanya, R. El-Bedewy – International Potato Center (CIP-SSA); B. Lemaga – PRAPACE.	Makerere $ 4,002 OSU $ 2,500 VA Tech $ 639 Rock $ 3,400

POST-HARVEST MANAGEMENT OF MOULDS AND MYCOTOXINS IN MAIZE AND GROUNDNUTS			
III.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 $ 5,891 VA Tech $ 22,316
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 – Makerere; V. Odeke – Extension Crop Protection Specialist; D.B. Taylor – VA Tech; J.M. Erbaugh – OSU; G. Turiho – Makerere.	Makerere $ 16,198 VA Tech $ 24,263 OSU $ 9,072
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 $ 4,180 OSU $ 1,000
IV.3	Regional IPM CRSP Symposium	E. Sabiiti, S. Kyamanywa – Makerere; G. Bigirwa, R. Ogwong – NARO; C. Omwega – ICIPE; A. Ekwamu – Rockefeller Forum.	Makerere $ 13,750
IV.4	Geographic Information Systems To Enhance IPM Collaborative Research in Uganda	L.S. Grossman, E.A. Roberts, J. Boyer – VA Tech; S. Kyamanywa – Makerere; NARO	Makerere $ 4,565 VA Tech $ 13,438
COFFEE WILT			
I.1	Etiology of Coffee Wilt	G.J. Hakiza – CORI; S. Miller – OSU.	CORI $ 19,195 OSU $ 27,849
I.2	Epidemiology of Coffee Wilt	G.J. Hakiza, D. Kyetere – CORI; H. Warren – VA Tech.	CORI $ 35,541 VA Tech $ 8,979
I.3	Host-Parasite Relationship	G.J. Hakiza, D. Kyetere – CORI; H. Warren – VA Tech.	CORI $ 28,133 VA Tech $ 15,304

Ninth Year Workplan for the Central American Sites in Guatemala and Honduras

Ninth 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.

I. 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

a. **Scientists:** G. Sullivan, J. Julian (U.S. graduate student), R. Edwards, S. Weller – PURDUE; G. Sánchez – Central American Institute for Agricultural Development (ICADA)[1]

b. **Status:** Continuing activity

c. **Objectives:** *Overall:* To develop sustainable NTAE programs in Central America. *Year 9:* (1) Continue to identify critical production, postharvest handling, and regulatory compliance (including food safety) problems, and assess their relative impact on regional competitiveness in the NTAE marketplace; (2) implement the model set of production, postharvest handling, and regulatory compliance (including food safety) policies and programs based upon performance-proven IPM regimes that enhance NTAE program sustainability; and (3) institutionalize performance-proven practices in the snow pea sector of Guatemala NTAE production.

d. **Hypotheses:** (1) Regional competitiveness in the NTAE marketplace can be correlated with the existence of institutionalized policies and programs that address economically sustainable production, postharvest, and regulatory compliance issues; and (2) NTAE programs that have institutionalized policies and programs to address critical production, postharvest handling and regulatory compliance issues are more successful in the international marketplace, and generate greater economic/socioeconomic benefits at the small producer and community levels.

e. **Description of research activities:** Interregional competitiveness is critical to long-term sustainability of NTAE programs. The transfer and institutionalization of performance-proven IPM production technology into the postharvest, preinspection, and forward

[1] ICADA is a NGO and is eligible to receive government grants and funding on the same basis as foundations and related non-profit organizations. All IPM CRSP collaborators in Guatemala (UVG, MAGA, ICTA, etc.) will receive their funding through ICADA.

distribution functions is essential for achieving regional competitiveness in the NTAE marketplace. This research continues to assess the impact of production, postharvest handling, and regulatory compliance (including food safety) has on market performance and economic/socioeconomic sustainability.

f. **Justification:** The market for NTAE's has become increasingly more competitive. The assurance of safe food supplies in an economically sustainable manner has become a major factor in determining interregional competitiveness. The results of this research help identify, develop, and institutionalize policies and programs that Central American NTAE programs need to increase competitiveness and enhance long-term sustainability.

g. **Relationship to other CRSP research activities at the site:** Provides baseline performance standards for institutionalizing performance-proven IPM production, postharvest handling and pre-inspection programs to achieve regulatory compliance in North American markets, and economic sustainability in the NTAE sectors.

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 assessment of production, post-harvest handling, and regulatory compliance issues in regional NTAE programs. Began initial data collection, collation, and assessment of NTAE program development on a regional basis. Established the performance protocols for GOG certified pre-inspection programs. Received $1 Million USD in collaboration with ICTA and ICADA (Institute for Agricultural Development in Central America) to establish the first fully integrated supply consolidation and pre-inspection center in the Solola region of Guatemala. Collaborated in the assessment of NTAE impact at the community and household level with Drs. Hamilton and Asturias.

i. **Projected outputs:** (1) Development of market-based, performance-proven critical production (HACCP), postharvest handling (preinspection), and regulatory compliance (including food safety) factors vital to long-term sustainability of NTAE programs; (2) institutionalization of critical policies and programs needed for achieving sustainable and competitive NTAE production in Central America; (3) increased standard of living and income stability for NTAE producers; (4) Ph.D. thesis and two journal publications; and (5) training programs to transfer performance-proven IPM / postharvest handling technology and knowledge to NTAE producers, technicians, and community leaders.

j. **Projected impacts:** Central American NTAE producers and exporters have witnessed a decline in regional competitiveness in U.S. markets due to increased food safety compliance standards. This activity will help improve regional competitiveness in the NTAE sector, thus enhancing the long-term sustainability of Guatemalan and Central American NTAE programs at the small producer and community levels. In addition, U.S. consumers will benefit from safe/high quality food supplies.

k. **Projected start:** October 1999

l. **Projected completion:** December 2002

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

n. **Budget:** PURDUE - $26,029 grad fee/assistantship (IPM CRSP); PURDUE - $19,192 (IPM CRSP)

I.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; R. Edwards – PURDUE; S. Hamilton – VPI; C. Reavis - TEXAS TECH (technical collaborator)

b. **Status:** Continuing 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 9:* (1) Survey IPM CRSP and non-IPM CRSP NTAE snow pea producers, their families, and field workers on health related issues;(2) take biological samples from test subjects to determine total toxic organics (TTO) and effects on human physiology; (3) collect and analyze samples of water to determine the TTO and toxic pathogens; and (4) develop a model for recommendations and interventions to improve rural health based on the findings of the surveys and bioassays.

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 IPM CRSP NTAE snow pea system on rural health will be continued in Year 9. The survey will focus 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 will be 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 at the site:** 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 final draft of the survey instrument is being evaluated by the Institute for Nutrition for Central America and Panama (INCAP). It is likely that INCAP will be included in data taking activities in the targeted villages. Additionally, 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. A proposal has also been submitted to USEPA, Government and International Services Branch, Office of Pesticide Programs, for this same purpose. Agencies and organizations in Guatemala that have been asked to participate in this project 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:** October 2000

l. **Projected completion:** September 2002

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

n. **Budget:** PURDUE - $23,885 (IPM CRSP); ICADA/Edwards - $13,014 1/2 grad fee/assistantship (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 – VPI; G. Sánchez - ICADA; G. Sullivan – PURDUE; L. Asturias – ESTUDIO 136O, C. Harris – VPI (technical collaborator)

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 9:* (1) To assess financial constraints to adoption and sustainable growth in production of targeted crops; (2) to assess marketing constraints to adoption and sustainable growth in production of targeted crops; and (3) to assess the relationships among financial markets, export crop markets and adoption of IPM by small-scale producers.

d. **Hypotheses:** (1) Access to credit increases likelihood of adoption of targeted crops; (2) more direct access to export markets increases income for producers; and (3) more direct access to markets and credit increases likelihood of continued production of target crops.

e. **Description of research activity:** Research will involve (1) a review of the literature concerning interactions of improved financial markets, access to financial markets, and access to commodity market outlets; (2) analysis of existing and proposed financial and marketing institutions in Chimaltenango; and (3) a survey of producers in several communities with differential access to financial and marketing institutions concerning their perceptions of credit and marketing needs and experience with financial and marketing institutions. The survey will be administered to at least 50 producers identified from previous work to represent the full range of socio-economic variation in the communities.

f. **Justification:** This activity will identify constraints to production and sustainable increases in income for small-scale producers of crops targeted by the IPM CRSP. Evidence concerning the relationship between availability of credit and the sustainable production of export crops is mixed. Some studies find that small-scale farmers are credit constrained; others argue that poor farmers do not want credit because they perceive that the risk for them is too great. Additionally, a number of programs, both public and private, have been instituted that attempt to increase access to credit for small-scale producers and these programs have used a variety of mechanisms to attempt to increase access and to ensure payback of loans. The proposed research will evaluate the degree to which financial markets in rural Chimaltenango constrain producers and the mechanisms most likely to improve access in a manner that will enable small-scale producers to absorb the risk inherent in taking out loans for high-value, high-risk crops. It has been hypothesized by a number of researchers that more direct market linkages enable producers to retain more of the revenues from their production—i.e. to capture more of the value added to their crops. The proposed research will evaluate the potential and observable effects of differing forms of access to export markets.

g. **Relationship to other CRSP activities at the site:** During year 8, male and female household heads in three communities in highland Guatemala were surveyed concerning their perceptions of the social and economic impacts of NTAE production for their own families and for their communities. Preliminary results indicate that the overall perception is that NTAE production has had positive social and economic impacts on producer households and in the community. Current and past producers were asked to name three things that would enable them to make more money from NTAE production. Interviews provided cues: "for example, do you need more land? Credit? Irrigation? Labor? Market access? Improved yields? Better product quality?" Most respondents stated that their most pressing need was money to invest in production or credit; more land was the second greatest need. Additionally, several farmers replied that higher yield, better prices, and new products or market outlets would help—all of which could be expected to contribute money for continued investment in NTAEs. The proposed research will contribute to an understanding of how to best help farmers obtain production finance and marketing channels in a manner that will contribute to the sustainable production of NTAEs.

h. **Progress to date:** Household surveys measuring social and economic impacts of NTAE production and of IPM adoption were carried out in 1998 and 1999. The impact perception survey described above was carried out in 2000-2001. Both of these activities produced evidence that NTAE production did not have some of the negative impacts attributed in much of the literature—such as decreasing incomes for many families and increasing inequality, the marginalization of women from economic resources, or decreasing quality of diets. Farmers indicated that production of target crops is a good way to support their families. The surveys also produced evidence that farmers could increase production if constraints were addressed and that methods to insure against risk are needed.

i. **Projected outputs:** (1) Reports of literature review, analysis of financial and marketing institutions, and survey results. (2) Policy recommendations. (3) one working paper or publication.

j. **Projected impacts:** Greater understanding of production constraints and the relationship between credit, marketing, and income should help to create policies that will ultimately produce sustainable income growth for small-scale producers.

k. **Projected start:** July 2000

l. **Projected completion:** September 2002

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

n. **Budget:** VPI - $17,942 (IPM CRSP); ICADA/Hamilton -$13,000 (GOG); PURDUE - $22,785 (IPM CRSP)

II. Assessment of Alternative Cropping Systems Including Biorational and Organic Approaches

II.1 Integration of IPM production strategies for prototype preinspection programs in NTAE crops

a. **Scientists:** S. Weller, G. Sullivan, R. Edwards. C. Mayen (Guatemalan graduate student) - PURDUE; G. Sánchez - ICADA

b. **Status:** Continuing activity. 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. Further, this research allows for expanding and strengthening IPM research capabilities in NTAE vegetable and fruit crops in Guatemala through graduate student training.

c. **Objectives:** *Overall:* Develop strong IPM research capabilities of Guatemalan cooperators in vegetable and fruit crop production; and generate 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 9:* (1) Establish field plots to investigate production practice alterations that reduce pest problems in vegetable production. These studies will build on previous IPM CRSP research results in pest management to investigate how soil management techniques affect crop growth and pest complexes (insects, disease and weeds). Results will contribute to total production system design and institutionalization of IPM programs in the NTAE sector necessary for success of preinspection programs. (2) Since papaya is a target crop in IPM CRSP programs, the graduate student will generate a database of pest and production problems facing

Guatemalan papaya growers with emphasis on fruit flies (Med fly) to guide future research programs in IPM.

d. **Hypotheses:** Fully tested and scientifically verified pest management programs will result in improved pest management strategies in NTAE crop production systems. Such programs will result in enhanced yields, reductions in pest levels and pesticide use and more rapid development of and acceptance of preinspection programs for NTAE crops.

e. **Description of research activity:** NTAE production practices should use integrated approaches to manage pests and reduce pesticide use along with pest levels. The 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.

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. Second, research conducted at Purdue University will investigate 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. Third, research is underway to develop an extensive database 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.

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 at the site:** 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:** This project will expand on our previous research.in vegetable and fruit production and cultivar improvement. The field aspects are beginning to consolidate our knowledge on how production practices can reduce pest infestation levels and lead to improved pest management. Field experiments with fresh market tomatoes are investigating how soil management coupled with threshold directed control practices can affect long-term pest populations. The papaya database being assembled will provide a roadmap for designing appropriate pest management research to address problems facing growers by use of IPM and ICM methods. 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 is the training of a skilled IPM researcher that 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 2002

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

n. **Budget:** ICADA/Mayen- $26,029 grad fee/assistantship (GOG); PURDUE - $27,317 (IPM CRSP)

II.2 Determination of the geographical distribution of *Plasmodiophora brassicae*, causal agent of clubroot in crucifer fields in Guatemala

a. Scientists: L. Calderon, D. Dardon – ICTA; R. Edwards, S. Weller – PURDUE

b. Status: New activity

c. Objectives: To develop a clubroot digital map, showing the infested areas in the highland regions where broccoli and other crucifer crops are grown.

d. Hypothesis: *P. brassicae* is present in most of the broccoli growing regions of the central and western highlands in Guatemala.

e. Description of research activity: Intensive sampling will be conducted during the broccoli-growing season (June-November) of years 2001 and 2002. Fields planted with crucifer crops will be visited and plants showing above-ground symptoms (wilting and yellowing) will be dug out and examined for radicular symptoms (clubroot). Measurements of incidence and severity will be recorded in the *P. brassicae*-contaminated soils. At the end of the growing season, a digital map will be obtained, indicating the contaminated areas.

f. Justification: Clubroot is presently the most damaging disease in broccoli, causing severe losses to many growers. Furthermore, the expansion of broccoli production into the western highlands is due in part to the impossibility of growing this crop in *P. brassicae* infested soils. The pathogen is easily spread by human labor or diseased speedlings, therefore it is of utmost importance to determine the present status of the organisms in the broccoli-growing regions of Guatemala.

g. Relationship to other CRSP research activities at the site: This study is a key component in the broccoli ICM research program, as clubroot is one of the main diseases affecting broccoli and which is very difficult to manage effectively.

h. Progress to date: New activity

i. Projected outputs: A digital map showing the current status of the *P. brassicae* dissemination in the Guatemalan highlands will be developed.

j. Projected impacts: A digital map, showing the present rate of spread of the disease will serve as baseline information to determine the future rate of spread of disease. It has long been assumed by growers and exporters alike that clubroot is expanding at a large rate in Guatemala. If this is proven true through this study, the map, showing severely affected areas and incipient ones will be a valuable tool in the educational process that needs to be implemented among broccoli growers, middlemen and packers, to stop the spread of the pathogen to uninfested soils.

k. **Projected start:** October 2001

l. **Projected completion:** November 2003

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

n. **Budget:** ICADA/ICTA $6,270 (GOG); ICADA- ARF/AGEXPRONT $8,030 (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. Sanchez, M. Palmieri – ICADA; S. Weller, R. Edwards, 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 9*: (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. **Hypotheses:** (1) Satisfactory control of PRSV-potyvirus can be achieved by the generation, micropropagation and planting of transgenic papaya, resistant to PRSV-potyvirus 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 this pest assessment and genetic engineering studies in close collaboration with ARF. 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 Zacapa 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. 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 ARF. 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 CRSP research activities at the site:** 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: Through funds acquired through the Guatemalan National Science and Technology Council, the plasmid construct has been engineered and inserted into an appropriate *Agrobacterium* vector. Somatic embryos have been successfully cultured in vitro. Transformants of both native papaya cultivars and Sunrise "solo"-type papayas (Hawaiian) are now being regenerated for greenhouse and field tests. New vectors had to be constructed with the kanamycin-resistant gene, as hygromicin vectors are now being phased out from bio-engineering programs. Currently, papaya transformation using the kanamycin-resistant vector is being conducted at the UVG laboratories.

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 $15,070 (IPM CRSP); ICADA / ARF/AGEXPRONT $12,595 (GOG); U. of GA - $3,250 (IPM CRSP); ICADA/U. of GA $2,500 (GOG)

II.4 Assessment of diseases, Mediterranean fruit fly populations and infestations in starfruit (*Averrhoa carambola*) and Asian guava.

a. Scientists: D. Dardon, L. Calderon – ICTA; L. Alvarez - ARF-AGEXPRONT; G. Sánchez - ICADA; R. Edwards, S. Weller, G. Sullivan- PURDUE

b. Status: Continuing activity

c. Objectives: *Overall:* (1) To study the preference and oviposition rated exhibited by fruits flies, mainly Ceratytis and native fruitflies on starfruit and Asian guavas grown in Guatemala for export purposes; and (2) to determine the main pests, other than fruit flies (insects and diseases) affecting the recently introduced Asian guava and starfruit cultivars.

d. Hypothesis: The production of med fly (and other fruit flies)-free starfruit and Asian guava to meet USA phytosanitary standards is feasible in Guatemala.

e. Description of research activity: To determine the infestation levels and population fluctuations of medflies and other native flies, established commercial plots will be selected and MacPhail and Jackson-type traps will be placed lured with appropriate materials. Traps will be monitored weekly to determine the density and population fluctuations of the main fruit fly species. The fruits will also be sampled to determine oviposition and larval infestation rates on fruits both under natural field conditions and forced infestation (caged trees subjected to fruit fly releasals). The Taiwanese cultural practice of covering fruits with a plastic cover will also be evaluated as a physical barrier against fruit fly infestation.

The procedure to be utilized for the assessment of insect pests and diseases will include: (1) visits to the different guava and starfruit growing regions, check background (growers interviews) information and assess the type and magnitude of damage caused by the encountered pests; (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.

f. Justification: Starfruit and Asian guavas have been targeted by ICTA and ARF as new crops that can be a very profitable cash crop for growers, in the local, regional and foreign markets. The starfruit and guava cultivars to be included in this study are Asian types that differ from the local cultivars in their sweetness and size, which makes them appropriate for fresh consumption. Given that international markets are currently highly competitive, it is imperative that the introduction of new export products needs enough production, handling and packing technology to ensure the quality of the product being exported.

g. Relationship to other CRSP research activity at this site: This activity is related to AGEXPRONT's and MAGA´S strategy of detecting and promoting new agricultural export products that may provide Guatemala a competitive edge in the international market. This new product search is part of AGEXPRONT´s 2000-2020 strategic planning.

h. Progress to date: Field plots have already been established in 3 and 4 locations in the Pacific Coast and eastern drylands of Guatemala, respectively.

i. Projected outputs: To demonstrate that production of fruitfly-free star and guava fruits is possible under Guatemalan field conditions, a necessary step to open US and other international markets.

j. Projected impacts: To provide growers located in the warm climates of Guatemala, a profitable and exportable cash crop that may represent an attractive option to traditional products such as field crops or locally consumed vegetables.

k. Projected start: October 2000

l. **Projected completion:** November 2002

m. **Projected person-months of scientist time per year:** 9 person-months

n. **Budget:** ICADA/ICTA $9,680 (GOG); ICADA -ARF/AGEXPRONT $9,350 (GOG); ICADA/Sanchez $12,560 (GOG)

II.5 Monitoring soil fertility and plant nutrition at the different projects conducted under the IPM-CRSP Program

a. **Scientists:** J. Leal - SOLUCIONES ANALÍTICAS; J. Sandoval - ICADA; S. Weller - PURDUE

b. **Status:** Continuing activity

c. **Objectives:** *Overall:* (1) To provide strong support on soil and foliar analyses for the different research programs of each institution involved in the IPM/CRSP program, including not only fertility but also food and water safety qualities; (2) to obtain nutrient uptake curves for the main crops being evaluated by the IPM CRSP, including snow peas and papaya; and (3) comparison evaluation of soil sustainability between ICM-managed sites and traditionally managed farms with specific emphasis on pest infestation levels. *Year 9:* To (1) conduct a diagnostic interpretation of the soil fertility status on each region and project that is being conducted on the IPM-CRSP program; (2) recognize and characterize the most important soils of the regions; (3) use soil tests and plant analysis as technical support tools to cultivate healthier crops and improve yields; (4) propose the appropriate management and fertilizer recommendations for each specific location to eliminate the fertility as limiting factor in production; (5) organize workshops to transfer the soil fertility and management practices to the farmer to improve the fertility programs of each region; (6) monitor the nitrate and phosphorus levels on the water sources of each region as pollution parameters; and (7) evaluate soil sustainability between ICM practices and traditional farming.

d. **Hypothesis:** The monitoring of soil fertility and plant nutritional levels plays a vital role in a crop's health and potential to resist pest infestations, and will result in the production of high yielding and high quality export crops.

e. **Description of research activity:** All the regions will be visited as needed with at least two visits per month. During the visits soil samples will be collected, follow by description and classification (under the USDA classification system) of the most important soils collected. During the growing season tissue samples will be taken. The fertility program will be recorded and new recommendations based on the information gathered will be proposed for the next cycle. For the most important crops several tissue samples will be taken at different growth stages. The nutritional level at each stage will be compared to the final productivity and soil fertility, so that a better understanding of the fertility factor can be acquired. Monitoring of pest infestations in low versus optimal nutrient situations will be done to verify that healthy crops resist pests better. Nutrient absorption curves will be obtained for each crop. The nitrate and phosphorus levels will be monitored on the water sources (water table principally) of each region, so that the impact on the environment can be determined. The increase on the use of fertilizer can increase the levels of these two nutrients on the water table and consequently have a negative impact on the environment.

f. **Justification:** With the information to be generated through the research herein described, sound long-lasting IPM strategies will be implemented to reduce the amounts of pesticides applied to the fields since, through better fertilization, healthier crops will be obtained; consequently this will result in satisfactory levels of insects and lower disease control. Several years of data collecting will be necessary to establish the ideal benefit-coast relation regarding soil fertility management and crop nutrition. By reducing the use of chemicals and the rational use of fertilizers, the environment will be preserved and the exposure of the farmers to harmful chemical agents will be decreased therefore increasing the quality of life.

g. **Relationship to other CRSP activities at the site:** This activity will have a strong collaborative component with the other institutions working on the IPM-CRSP program, since all the sites will be analyzed and a specific fertility program and nutritional crop status will be implemented and monitored on each site. The traditional fertility programs will be compared to the new fertilizer recommendations and its effect in the plants. It is important to note that some research proposals from the institutions working with IPM-CRSP program are using organic sources, which also will be considered in this research. The nutritional aspect of crop production and its impact on crop health and pest susceptibility is critical for the development of effective integrated crop production systems. Pest management is the primary focus of the IPM CRSP; however, nutrient management and its effects on crop susceptibility or resistance to pest infestations is an integral part of all our crop management and production system development. Overall, economically and environmentally sustainable NTAE production is dependant on a total systems approach that fully integrates pest management with other aspects of crop culture.

h. **Progress to date:** Soil fertility data has been collected for Xenimajuyu and Xeabaj, two of the main IPM CRSP research communities in the central highlands of Guatemala. Results show that soil fertility management can be significantly improved, as a wide range of fertility problems were detected, among them, low soil pH and excessive accumulation of macronutrients. Preliminary studies in water quality have shown high concentrations of phosphorus and nitrates, which may be hazardous for human consumption.

i. **Projected outputs:** Concrete information regarding the soil chemical and physical characteristics at the different regions in which the IPM-CRSP is working will be obtained. Transfer of information to the farmers. Written information. Workshops Nutrient absorption curves for each crop being grown at these sites will be developed. The nitrate and phosphorus levels from the water resources will be monitored. Specific fertility programs will be recommended for each characterized soil and crop being grown. The correct and rational use of chemical fertilizers will be implemented and the organic sources used by the farmer will be considered. A workshop will be organized to transfer the new findings to the farmer so that they will be able to know more about their soils and implement new fertility programs. Added outputs resulting from food and water quality analyses will result in: (1) help preventing diseases in the communities; (2) better use of the resources and; (3) greater income and quality of life for the farmers and their families.

j. **Projected impacts:** (1.) A better understanding of the soil chemical and physical characteristics at different regions where information recorded so far is negligible; (2) determination of the nutrient absorption curves for the crops being grown on these regions that will help improve yields and lower pests levels in the field; (3) by rationally usage of chemical fertilizers and lowering pesticide use, the environment will be protected; (4) eliminate the nutritional component as a limiting yield factor, according to characteristics found in each specific region and crop; (5) agricultural practices recommendations oriented to reduce the abuse of soil degradation and improve its sustainability; and (6) integration of these soil conservation practices into the ICM programs pursued by the IPM-CRSP.

k. **Projected start:** September 1999

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

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

n. **Budget:** ICADA/Soluciones Analíticas - $19,360 (GOG)

II.6 Identification, distribution and epidemiology of plant virus pathogens that threaten pepper / tomato and cucurbit production in Honduras

a. **Scientists:** D. Krigsvold, J.M. Rivera, J.Melgar - FHIA, Honduras; A. Rueda, M. Mercedes Roca de Doyle, E. Aquilar – EAP/Zamorano; M. Palmeiri, – UVG; R. Martyn, G. Sullivan – PURDUE; J. Brown – Univ. of Arizona (technical collaborator)

b. **Status**: New activity

c. **Objectives:** *Overall:* The proposed activity is envisioned as a three-year project. Preliminary studies have been conducted in several locations in Honduras and Guatemala, in order to prioritize the areas of focus for subsequent work. Several plant virus diseases that threaten vegetable production have been identified, necessitating the need for additional in-depth studies. Because interaction among different plants and their pests affect the epidemiology of the diseases, a systems approach is essential to the success of an integrated crop management approach. The first year's focus involves identifying and determining the distribution of the most economically important viruses in pepper and tomatoes in several economically important areas in Honduras (Comayagua Valley,

Francisco Morazan Region, and the Juticalpa area of Olancho) and in Zacapa Valley in Guatemala**.** Virus detection and identification will be accomplished using established serologically- and PCR-based diagnostic methods appropriate for the detection of plant viruses most commonly found in these crops. Virus presence and associated disease severity will be assessed to establish a baseline inventory of the specific viruses present in this cropping system. Farmers will be queried in a survey to determine the kinds of practices typically employed to control perceived virus disease problems, with an emphasis on identifying potential misapplication of hard chemicals or other approaches not in line with effective disease control. A fact sheet for each important virus will be compiled toward a field guidebook to aid in devising workable control approaches. Fact sheets will include photos and symptom descriptions to enable preliminary identification of the most common viral diseases, and provide information on virus host range, specific vector and transmission parameters, seed and/or mechanical transmissibility, and resistant crop varieties or other available control strategies.
Subsequent Years: (1) Identify and map the main plant viruses present in the important cropping systems of Honduras; (2) establish the identity and distribution of *Bemisia tabaci* vector biotypes in vegetable cropping systems in Honduras using a molecular marker approach; and (3) transfer technology for virus identification: molecular cloning techniques for virus identification and whitefly biotyping to EAP / ZAMORANO and Universidad Del Valle.

d. **Hypotheses:** (1) Plant viruses, and specifically the whitefly-transmitted geminiviruses, are important limiting factors in vegetable cropping systems in Honduras and Guatemala; (2) little if any information is available to farmers regarding specific plant viruses that limit vegetable crop production, and disease control practices are often misguided, leading to application of chemicals that have no affect on virus pathogens; and (3) local farmers are currently employing control strategies that are not effective against viruses and, thus cost the farmer needless money.

e. Description of research activity:
SAMPLE COLLECTION

Target area, sampling pressure and sample numbers. A total of 260 leaf tissue samples will be collected in Honduras in three geographical areas during two consecutive cropping seasons starting on September 2001, as follows.

	# of Samples (% of Grand Total)		
Sampling area	**EAP**	**FHIA**	**Total Samples**
Comayagua Valley	80 (30.7)	80 (30.7)	160 (61.5)
Olancho	00 (00)	80 (30.7)	80 (30.7)
Francisco Morazán	20 (7.7)	00 (00)	20 (7.7)
Subtotal	**100 (38.4)**	**160 (61.4)**	------------
Grand total			**260 (100.0)**

There are two cropping seasons, August through November 2001 and January through April 2002, and they are representative both of different environmental conditions and probably of different insect/virus-disease problems. Half of the total samples will be obtained in each cropping season, including pepper and tomato.

Sampling scheme and chronology. In each cropping season, in each field 4 samples per crop will be collected at 25 days and 50 days after transplanting; thus, a total of eight samples of tomato or of pepper should be collected at each separate field in the two cropping seasons. Every effort will be made to assure that pepper and tomato are equally represented in number of samples per sampling area. Thus, in the case of FHIA at the Comayagua Valley area, it is expected that in one cropping season the survey will produce 20 samples from tomato and 20 samples from pepper, to total 40 samples per season to be analyzed. Ideally both tomato and pepper samples will be obtained from the same field, which would mean that a total of five fields could be sampled simultaneously for both crops. Otherwise, samples will be obtained from different fields.

Documentation of cases. All samples taken will be documented in a specially-designed format with the symptoms and circumstances of occurrence of the problem (crop history, prevalent weather, distribution and frequency, etc.,). In addition, each case will be photographed in the field using a digital camera for the development of photographic archives and preparation of a field guide.

Processing of samples. Each sample will be tested by means of ELISA against a battery of 12 different viruses and by PCR for Geminivirus using specific primers. All samples collected by each party will be tested at the respective laboratory and all those testing positive for Geminivirus will be sent to Dr. Judy Brown at The University of Arizona for cloning and sequencing. Molecular identification will involve cloning, sequencing, and sequence comparison using the GEMINIDETECT*ive*. In addition, technology transfer of components of these techniques to FHIA, EAP and Universidad del Valle will be important components of this project. For purposes of quality control and cross-checking, 10 percent of the samples collected by each institution in Honduras will be sent to the other local institution and to Dr. Brown, all of whom will process them to check for replicative results.

Training. Personnel of both FHIA and EAP directly involved in the project will visit each other's laboratories for the purpose of training and standardization of procedures.

Training of FHIA's personnel. During the first three months of the project. Dr. José C. Melgar, Head Plant Pathology at FHIA, will be trained with Dr. Brown at Arizona for 2 weeks on molecular detection of viruses by PCR (and other associated techniques) and at EAP on the ELISA technique.

f. **Justification:** Vegetables constitute an important source of food and income for many Honduran and Central American Farmers. These products are cultivated for NTAE trade and local consumption, and have the potential of becoming important export crops; cucurbits are already one of the most important fruit crops for export. Among the most important limiting factors are plant virus diseases that are little understood and mismanaged. Before rational management strategies can be implemented, it is necessary to determine the causes of the diseases and to identify, if possible, the virus reservoirs. In some cases, seed harboring a virus is planted by farmers, thereby initiating the disease. Clean seed programs are essential to successful crop production. Collectively, this knowledge will subsequently allow the development of disease management strategies to increase production and yields. Among viral infections, geminiviruses transmitted by whiteflies constitute a complex problem that requires an integrated crop management approach. There are other important viral diseases of vegetable crops that must also be understood and prioritized in developing integrated management approaches. 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 populations will result in reduced application of hard insecticidal chemistries, thereby encouraging environmentally safer production practices in Honduras and Guatemala.

g. **Relationship to other CRSP research activities at this site:** This project has complementary efforts in Guatemala to determine the composition of plant viruses and whitefly vector in vegetable cropping systems.

h. **Progress to date:** To date, certain ELISA and PCR methodologies have been established and optimized in the laboratories of FHIA, EAP, and Universidad Del Valle. Optimization of ELISA methods (Indirect, DAS-ELISA and DABI) and PCR methodologies has been accomplished collaboratively between Arizona and Zamorano and Del Valle, respectively. Universal PCR primers and methodologies for geminivirus detection and subsequent identification have been provided by the Arizona laboratory. Additional primers have been provided to Del Valle and PCR with these primers is currently being optimized.

i. **Projected outputs:** (1) Establishment of ELISA and PCR methodologies for detection and identification of important plant viruses at FHIA, EAP, and Del Valle; (2) strengthen collaborative interactions between scientists as FHIA, EAP, Del Valle, and Arizona; (3) student thesis with conclusions about identity and distribution of plant viruses in vegetable cropping systems (with an emphasis on peppers and tomatoes) in the three specified regions of Honduras; (4) scientific abstract, Disease Note, and/or article resulting from preliminary survey data; and (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.

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 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.

k. **Projected start:** September 2001

l. **Projected completion**: September 2004

m. **Projected person-months of scientist time per year:** 15 person-months

n. **Budget:** PURDUE - $6,500 (IPM CRSP); FHIA/Honduras - $25,000 (GOH); EPA/Zamorano - $26,731 (GOH); U. of AZ – $48,269 (GOH)

III. Biological Control Techniques

III. **Biological Control Techniques** (this activity was moved from IV.3 in Year 8 workplan, to more closely represent research proposed).

III.1 Evaluation of *Brassica* organic residues as soil biofumigants and solarization in broccoli

a. **Scientists:** L. Calderon, D. Dardon, F. Solís, H. Carranza, M. Morales – ICTA; R.Edwards - PURDUE

b. Status: Continuing activity

c. Objectives: *Overall*: (1) To determine if the utilization of crop residues as soil biofumigant has any beneficial effects on broccoli 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; and (4) to establish the production costs and profitability of biofumigation in broccoli.

d. Hypothesis: (1) Biofumigation is an effective alternative to Methyl bromide for soil disinfestation purposes in broccoli grown in Guatemala; and (2) biofumigation is an agricultural practice that enhances the soil fertility and plant nutrition of broccoli 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 at two localities. Treatments 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. 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 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 release of methyl isothiocynate into the soil.

g. Relationship to other CRSP research activities at the site: This study is complementary to other IPM activities carried out in melons, including the study of foliar bacterial diseases and nematode root damage. If proven effective, this technology can be included in organic crop production, which has been targeted as a priority area, by AGEXPRONT, in the expansion of horticultural exports being grown in Guatemala.

h. Progress to date: Research found that biofumigation with solarization is beneficial to soil health through addition of nutrients and improved soil structure; provides some weed suppression, although disease effects are still being evaluated; and results in acceptable yields. Treatments with wild *Brassica* spp and broccoli residues have potential as acceptable alternatives to methyl bromide for use in broccoli production.

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 an 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.

k. **Projected start:** July 2000

l. **Projected completion:** June 2002

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

n. **Budget:** ICADA/ICTA $6,350 (GOG)

IV. Strategically Targeted Disease and Insect Control

IV.1 Institutionalization of a quality control preinspection process in the production and export of snow peas in Guatemala

a. **Scientists:** G. Sanchez – ICADA; G. Sullivan, S. Weller, R. Edwards – PURDUE; J. Sandoval – ARF/AGEXPRONT; L. Caniz - APHIS-IS/Guatemala

b. **Status:** Continuing activity

c. **Objectives:** *Overall:* To implement fully integrated IPM CRSP developed programs based on previous performance-tested IPM strategies and quality control program in snow peas. Such programs are 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 leaf miner crisis; (3) to produce high quality snow peas that are safe to consumers and grown in a sustainable production system; and (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 9 objectives:* Implement, in collaboration with PIPAA (AGEXPRONT´s Integrated program for the protection of the environment and agriculture) and the Ministry of Agriculture (MAGA), fully operational IPM protocols (based on previous IPM CRSP research) for totally integrated crop management (ICM) for snow pea production, post-harvest handling and export 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 at site:** 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 ICTA, ARF, Purdue and Del Valle Universities 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 and EXOTIC, S.A. PIPAA and the IPM-CRSP are developing the training manuals for inspectors and field ICM guidelines for growers. These manuals will be ready by August 2001, and distributed to growers in September 2001.

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 2002

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

n. **Budget:** ICADA/Sanchez $50,820 (GOG); ICADA/APHIS-IS $9,900 (GOG)

IV.2 Integration of Telemetric measurement of the climatic factors involved in the population dynamics of leaf miners (*Liriomyza huidobrensis*) and *Ascochyta pisi* in snow peas into IPM CRSP developed pest management programs.

a. **Scientists:** L. Calderon, D. Dardon, F. Solís – ICTA; R. Edwards – PURDUE

b. **Status:** New activity

c. **Objectives:** *Overall:* Integrate prediction models derived from measurements of temperature, relative humidity and rainfall for Ascochyta leaf and pod blight and leaf miner populations in snow peas, into a total system IPM CRSP approach to pest management in snow peas.

d. **Hypothesis:** Development of mathematical models of climatic factors will enhance IPM based programs for control of leaf miners and 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. These data will be used to develop a mathematical model for predicting of suitable environmental conditions for the reproduction of leaf miners and growth and dissemination of *Ascochyta pisi*. The model will be incorporated into previously developed IPM practices to refine and improve pest management practices.

f. **Justification:** This research represents an important component of ICTA’s activities to develop mathematical models for use in the prediction of pest outbreaks. Such models developed for certain diseases play a key role in the management of important agricultural pests and are important components of effective IPM Programs.

g. Relationship to other CRSP research activities at site: This study complements previous and current IPM research activities in snow peas. The research described will 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: new activity

i. Projected outputs: (1) More effective IPM based management of leaf miner and *Ascochyta pisi*, the causal agent of Ascochyta blight in snow peas.

j. Projected impacts: To provide growers with a warning system for precision application of IPM practices 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

n. Budget: ICADA/ICTA $5,390 (GOG)

IV.3 Evaluation of sexual pheromones traps in IPM management programs of *Plutella xylostella* (Lepidoptera: Yponomeutidae) in broccoli

a. Scientists: H. Carranza, D. Dardon, L. Calderon – ICTA; R. Edwards - PURDUE

b. Status: New activity

c. Objectives: *Overall:* (1) Determine if traps baited with attractant sexual pheromones reduce the populations of *P. xylostella* in broccoli fields; and (2) Compare the effectiveness of P. xylostella sexual pheromone traps, placed on the perimeter of broccoli fields vs. traps placed in the middle of the fields.

d. Hypothesis: Sexual pheromones traps will assist other IPM strategies for improvement in management and control of *P. xylostella*.

e. Description of research activity: The evaluation will be done in Chimaltenango from August 2001 through March 2002. Four experiments will be conducted in 2002. Two will be conducted in the rainy season and two will be conducted in the dry season. The plots will be 400 m^2 in size. Treatments will include sexual pheromone traps, placed on the perimeter of broccoli field or the middle of the field and each will be compared to no trapping. The experimental design will consist of paired plots for “t” tests, in which each trap-placement treatment will have a specific control plot. After conducting the student “t” test, the best treatment will be selected, and used in future experiments to design appropriate IPM approaches to pest management. Quantifiable factors include: (1) the presence of larvae and pupas in the foliage will be assessed visually once a week, selecting 20 broccoli plants/treatment at random and counting the total numbers of *P. xylostella* larva and pupae; (2) gross yield in kg/ha; (3) export-quality yields (kgs/ha); and (4) records of all variable costs will be kept to compare the profitability between treatments. Broccoli will be managed according to the agronomic recommendations contained in the Integrated Management of Pests in Broccoli, a document generated by the project MIP ICTA-CATIE-ARF-IPM CRSP.

f. **Justification:** The use of synthetic sexual pheromones in other countries has been successfully used for reducing populations of *P. xylostella* and the need for high numbers of synthetic insecticide applications. Presently, lepidopteran larvae are controlled with microbiological products such as BT's; however, in other countries *P. xylostella* has has developed resistance to these products. In Guatemala, *P. xylostella* is beginning to show indications of resistance to the aizawi subspecies of B. thuringiensis. Preliminary studies conducted in Guatemala suggest that the use of pheromone traps reduced the numbers of *P. xylostella* eggs and larvae in the heads and leaves of broccoli plants.

g. **Relationship to other IPM CRSP activities at the site:** The use of sexual pheromone traps will complement the information generated by the IPM CRSP project ESTUDIOS 1360, ALTERTEC, AGRILAB, and the Universidad del Valle de Guatemala.

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

i. **Expected outputs:** The integration of etiological tactics (sexual pheromone traps) into the IPM strategy utilized in broccoli for the management of *P. xylostella*.

j. **Expected impacts:** Development of new IPM tactics for the management of *P. xylostella*. The establishment of sexual pheromone traps in broccoli will allow: (1) reductions in the use of pesticides and (2) offer a safer, healthier product to consumers.

k. **Projected start:** August 2001

l. **Projected completion:** March 2002

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

n. **Budget:** ICADA/ICTA $4,455 (GOG)

IV.4 Integrated Pest Management in Broccoli

a. **Scientists:** H. Carranza, D. Dardon, L. Calderon – ICTA; R. Edwards, S. Weller PURDUE

b. **Status:** Continuing activity

c. **Objectives:** *Overall:* To validate, at the field level, an IPM program for broccoli, designed from the integration of tactics previously tested individually.

d. **Hypothesis:** In contrast to traditional growers' technology, the IPM program for broccoli is a more efficient pest management technology, resulting in higher yields and increased profits.

e. **Description of research activities:**

Broccoli. Six 1,200 m^2 broccoli IPM test plots will be established in different Chimaltenango sites and compared to traditional technology employed by growers. The IPM package will include the following components: (1) speedling transplants (in contrast to seedbed seedlings); (2) application of imidachloprid at transplant; (3) application of BT-based pesticides for lepidopteran larvae; and (4) utilization of economic damage thresholds (EDT) for aphids and lepidopteran larvae. Scouting for insect pests will be done twice a week, by inspecting 25 randomly chosen plants. EDT for lepidopteran larvae (*Trichoplusia, Leptophobia* and *Plutella*) will be 5 or more larvae in 25 plants. The factors to be quantified are yield (export-quality broccoli heads) and profitability of the two systems.

f. **Justification:** This research is an integration of previous IPM CRSP work, in which different IPM tactics were evaluated, primarily against white grub (*Phyllophaga* sp) and lepidopteran larvae (*Plutella xylostella, Trichoplusia ni and Leptophobia aripa*). The integration of the most promising tactics into an effective IPM program for broccoli is one of the main goals of the IPM CRSP and its private sector collaborators in Guatemala. The export of broccoli with reduced pesticide content will enhance the consumers' and producers safety.

g. **Relationship to other CRSP activities at the site:** This work is a result of previous work done on individual management tactics for broccoli insect pests, in which ICTA, GEXPRONT and Purdue University have had close collaboration

h. **Progress to date:** Results have shown that ICM strategies applied to Broccoli result in increased profits and reduced usage of pesticides.

i. **Projected outputs:** An IPM program for the main insect pests in broccoli, mainly lepidopteran pests (*Plutella xylostella, Trichoplusia ni, Leptophobia aripa*), aphids and white grubs (*Phyllophaga spp.)*.

j. **Projected impacts:** The adoption of the IPM program by broccoli growers in Guatemala, disseminated by the packing and export companies associated to AGEXPRONT

k. **Projected start:** June 2000

l. **Projected completion:** October 2002

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

n. Budget: ICADA/ICTA $7,150 (GOG)

SUMMARY OF RESEARCH ACTIVITIES - NINTH YEAR WORKPLAN FOR THE CENTRAL AMERICAN SITES IN GUATEMALA AND HONDURAS
(September 30, 2001 – September 29, 2002)

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 (U.S. graduate student), R. Edwards, S. Weller – PURDUE; G. Sánchez – Central American Institute for Agricultural Development (ICADA)	PURDUE - $26,029 grad fee/ assistantship (IPM CRSP); PURDUE - $19,192 (IPM CRSP)
I.2 Assessment of the impact on rural health of IPM CRSP technology adoption in the NTAE snow pea production system	G. Sánchez – ICADA; L. Asturias ESTUDIO 1360; R. Edwards – PURDUE; S. Hamilton – VPI; C. Reavis - TEXAS TECH (technical collaborator)	PURDUE - $23,885 (IPM CRSP); ICADA/Edwards - $13,014 1/2 grad fee/assistantship (GOG)
I.3. Economic and socioeconomic impact assessment of IPM and nontraditional crop production strategies on small farm households in Guatemala	S. Hamilton – VPI; G. Sánchez - ICADA; G. Sullivan – PURDUE; L. Asturias – ESTUDIO 136O, C. Harris – VPI (technical collaborator)	VPI - $17,942 (IPM CRSP); ICADA/ Hamilton -$13,000 (GOG); PURDUE - $22,785 (IPM CRSP)
Assessment of Alternative Cropping Systems Including Biorational and Organic Approaches		
II.1 Integration of IPM production strategies for prototype preinspection programs in NTAE crops	S. Weller, G. Sullivan, R. Edwards. C. Mayen (Guatemalan graduate student) - PURDUE; G. Sánchez - ICADA	ICADA/Mayen- $26,029 grad fee/assistantship (GOG); PURDUE - $27,317 (IPM CRSP)
II.2 Determination of the geographical distribution of	L. Calderon, D. Dardon – ICTA; R. Edwards, S. Weller –	ICADA/ICTA $6,270 (GOG); ICADA-

Plasmodiophora brassicae, causal agent of clubroot in crucifer fields in Guatemala	PURDUE	ARF/AGEXPRONT $8,030 (GOG)

II.3 Assessment of insect pest and diseases, integrated pest management studies and development of PRSV-resistant plants in "solo-type" Hawaiian papayas	G. Sanchez, M. Palmieri – ICADA; S. Weller, R. Edwards, G. Sullivan – PURDUE; L. Calderon, D. Dardon – ICTA; W. Parrott, M. Deom – U. of GEORGIA	ICADA/Sanchez $15,070 (IPM CRSP); ICADA/ARF/ AGEXPRONT $12,595 (GOG); U. of GA - $3,250 (IPM CRSP); ICADA/U. of GA $2,500 (GOG)
II.4 Assessment of diseases, Mediterranean fruit fly populations and infestations in starfruit (*Averrhoa carambola*) and Asian guava	D. Dardon, L. Calderon – ICTA; L. Alvarez - ARF-AGEXPRONT; G. Sánchez - ICADA; R. Edwards, S. Weller, G. Sullivan- PURDUE	ICADA/ICTA $9,680 (GOG); ICADA -ARF/AGEXPRONT $9,350 (GOG); ICADA/Sanchez $12,560 (GOG)
II.5 Monitoring soil fertility and plant nutrition at the different projects conducted under the IPM-CRSP Program	J. Leal - SOLUCIONES ANALÍTICAS; J. Sandoval - ICADA; S. Weller - PURDUE	ICADA/Soluciones Analíticas - $19,360 (GOG)
II.6 Identification, distribution and epidemiology of plant virus pathogens that threaten pepper / tomato and cucurbit production in Honduras	D. Krigsvold, J.M. Rivera, J.Melgar - FHIA, Honduras; A. Rueda, M. Mercedes Roca de Doyle, E. Aquilar – EAP/Zamorano; M. Palmeiri, – UVG; R. Martyn, G. Sullivan – PURDUE; J. Brown – Univ. of Arizona (technical collaborator)	PURDUE - $6,500 (IPM CRSP); FHIA/Honduras - $25,000 (GOH); EPA/Zamorano - $26,731 (GOH); U. of AZ – $48,269 (GOH)
Biological Control Techniques (this activity was moved from IV.3 in Year 8 workplan, to more closely represent research proposed).		

III.1 Evaluation of *Brassica* organic residues as soil biofumigants and solarization in broccoli	L. Calderon, D. Dardon, F. Solís, H. Carranza, M. Morales – ICTA; R.Edwards - PURDUE	ICADA/ICTA $6,350 (GOG)

Strategically Targeted Disease and Insect Control		
IV.1 Institutionalization of a quality control pre-inspection process in the production and export of snow peas in Guatemala	G. Sanchez – ICADA; G. Sullivan, S. Weller, R. Edwards – PURDUE; J. Sandoval – ARF/AGEXPRONT; L. Caniz - APHIS-IS/Guatemala	ICADA/Sanchez $50,820 (GOG); ICADA/APHIS-IS $9,900 (GOG)
IV.2 Integration of Telemetric measurement of the climatic factors involved in the population dynamics of leaf miners (*Liriomyza huidobrensis*) and *Ascochyta pisi* in snow peas into IPM CRSP developed pest management programs	L. Calderon, D. Dardon, F. Solís – ICTA; R. Edwards – PURDUE	ICADA/ICTA $5,390 (GOG)
IV.3 Evaluation of sexual pheromones traps in IPM management programs of *Plutella xylostella* (Lepidoptera: Yponomeutidae) in broccoli	H. Carranza, D. Dardon, L. Calderon – ICTA; R. Edwards - PURDUE	ICADA/ICTA $4,455 (GOG)
IV.4 Integrated Pest Management in Broccoli	H. Carranza, D. Dardon, L. Calderon – ICTA; R. Edwards, S. Weller PURDUE	ICADA/ICTA $7,150 (GOG)

Ninth Year Work Plan for South American Site in Ecuador

In year 9, the IPM CRSP will begin its fifth 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 on non-traditional export crops with strong export potential. Socioeconomic analyses address three primary issues: impact assessment and adoption, with a significant gender component. The Ecuador research is integrated with collaborating projects on the Soils CRSP, a health impacts project of CIP and a Canadian-funded project called Eco-salud.

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 Quevado 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 whereever possible to help institutionalize knowledge and interest in IPM. International and U.S. institutions contributing to the IPM CRSP program in Ecuador include CIP, Ohio State, Georgia, Florida A&M, and Virginia Tech.

I. Pest Monitoring and Diagnosis

I. 1 Survey of the incidence and economic importance of nematodes in Plantain

a. **Scientists:** Principal investigators - Randy Rivera, C. Suárez, C. Triviño; Colaborative scientists: Mike Ellis (Ohio State), Danilo Vera.

b. **Status**: Continuing activity

c. **Objectives (Overall and current year):** Determine the incidence of nematodes in plantain and evaluate their relative importance to the crop.

d. **Hypothesis:** Plantain root damage due to *Meloydogyne sp* is more important than *Radopholus sp* or that caused by other species.

e. **Description of research approach**: This research consists primarily of a survey, laboratory assessment of samples and data analysis. The survey will be carried on throughout the "plantain belt", around El Carmen (Low technology) and Quevedo (Medium to high technology). Two visits will be made to each plot, covering both the rainy and dry seasons. At each visit, root and soil samples will be collected for nematode assessment in the laboratory. Both samples will be processed to determine nematode incidence by type and root damage. The quantity of root loss (by volume according to routine procedure) will be established.

f. **Justification**: Plantain yield in Ecuador is generally low, national averages are about 8 MT/ha out of a 15 MT/ha potential. Apart from the foliar pathogen causing Sigatoka disease, corm and root damage due to nematode attack play a major role in low yields. Plantain belongs to the *musaceae* family, the same as banana, and it was assumed that same pathogens attack both crops. Therefore, it was expected that populations of *Radopholus similis* would be associated with root damage in plantain. However, the work being conducted during the last two years under the IPM/CRSP has shown very low or no incidence of *R. Similis* and relatively larger populations of *Meloidogine spp*. CRSP results also show that none of the nematode species has reached threshold levels (at least 1000 nematodes per cubic centimeter of roots or soil). No study of this sort has 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. These technologies are being developed in other CRSP activity within the same area.

h. **Progress to date**: Previous to designing the survey, trials are being conducted to adjust collecting methods and procedures to plantain. A student is being trained on sample processing and identification of nematodes by gender.

i. **Projected outputs**: (1) Clear information on root diseases caused by nematodes in plantain; and (2) 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 results will allow p lanning control decisions as part of the integrated management of the crop. It will serve as baseline for future work on control measures. Personnel will also be trained.

k. **Project Start**: September 2000

l. **Completion**: September 2002

m. **Person months**: 12

n. **Budget for year 9:** USD $4,625 (INIAP)

II. Development of IPM Practices

II.1 Development of late blight management strategies for resistant potato cultivars in Ecuador: Not Funded

II. 2 Development of Biocontrol methods for two major potato pests in Ecuador: The Andean Potato Weevil, *Premnoptrypes vorax*, and the Central American tuber moth, *Tecia solanivora*

a. **Scientists**: Patricio Gallegos, César Asaquibay, Sandra Garcés, Geovanny Suquillo INIAP, Aziz Lagnaoui (CIP) and Roger Williams, Ohio State University.

b. **Status:** Continuing activity.

c. **Objectives: (overall)** (1) To reduce the losses caused by these 2 potato pests and (2) to lower the risk to the health of farmers and consumers through biological control and with products of low toxicity. **(current year):** (1) Test the efficacy of an Insect Growth Regulator (Triflumuron), applied in localized areas (different plant level and select plants within a field) for the control of Andean potato weevil (2) develop alternative biological control methods for the two pests.

d. Hypotheses: (1) The Insect growth regulator (Triflumuron) can control *P. vorax*, regardless of where it is applied in the field. (2) *Metarhizium* and *Beauveria* are effective against Andean potato weevil adults; and (3) the application method of Baculovirus, together with improved storage, will result in better control of *Tecia solanivora* in storage.

e. **Description of research activities:**

(1) Control of *P. vorax* using an Insect Growth Regulator (the chitin inhibitor, Triflumuron). Spray treatments will be applied to the whole plant and to the lower half of the plant, all potato rows and alternate rows. An untreated check will be used to compare treatments. Sprays will be applied at 40, 60 and 80 days after emergence. Treatments will be replicated 5 times and arranged in a completely randomized block design. The experimental unit will consist of 6 rows, 8m long. At 40 days, leaf damage will be evaluated every 15 days until harvest when tubers will be evaluated for larval damage.

(2) Biological control of *P. vorax*: Local strains of the entomopathogenic fungi *Beauveria sp. (2 strains)* and *Metarhizium* sp. (6 strains), available in the Department of Vegetable Protection, INIAP, will be tested in the laboratory for effectiveness against of *P. vorax* adults. Treatments, consisting of 20 insects, will be replicated 5 times in a completely randomized block design. Fungal Infection and Mortality will be evaluated at 15, 30, 45 and 60 days after application. The most pathogenic strains will be selected and used in baited traps in the field. The evaluation will correspond to the number of infected and dead insects in the surrounding area of the traps. Persistence of the fungal treatment will be evaluated by exposing laboratory-reared insects to treated foliage at 5, 10 and 15 days after application.

(3) Management of *Tecia solanivora* in storage. In this experiment, we will test 2 types of formulation of the Baculovirus (dust and solution) under 2 storage systems

commonly used by farmers (silos and sacs). In each storage system, 3 treatments will be considered 1) an untreated check, 2) Baculovirus dust, and 3) Baculovirus in solution. In the silos, treatments will consist of 50kg of stored potatoes replicated 3 times for a total of 150 kg. The potato sacs, 25 kg each will be considered as a unit replicated 6 times for a total of 150 kg/treatment. All treatments will be artificially infested with *Tecia solanivora*. Tubers will be evaluated for infestation every month and for the duration of the storage period. A total of 100 tubers will be randomly selected and scored for *Tecia* damage.

f. **Justification:** The Andean potato weevil and the Central American tuber moth are both very devastating pests of potato in both field and storage. Farmers regularly use very toxic chemical pesticides to control them. The strategy to deal with these pests is 2 folds, in a short term, replace highly toxic compounds with the use of lesser toxic chemicals such as the IGR (Triflumuron – Green Label LD50 of 5000mg/kg). Previous work at INIAP provides evidence on the presence of entomopathogenic fungi and on the effectiveness of baited traps against the APW. A better understanding of the baited traps and use of entomopathogenic fungi will help in devising a strategy based on spot treatment using biological control methods. This method will reduce production costs and unnecessary exposure to toxic chemicals. Previous work of CIP scientists and collaborators provides ample evidence of the effectiveness of Biological products (*Bacillus thuringiensis* and Baculoviruses) against *Tecia solanivora* in storage. The use of these products on ware potatoes will significantly reduce the unnecessary exposure to toxic chemical pesticides of farmers and consumers.

g. **Relationship to other CRSP activities:** This project is linked to several on-going CIP IPM projects in Ecuador. Principal among these are: 1) Diversity of pathogenic Baculoviruses of *Tecia solanivora* (CIP-IRD-PUCE-INIAP), 2) Project Eco-Salud seeking better health for farmers and 3) CIP-FAO farmer field school project, testing IPM technologies with farmers.

h. **Progress to Date:** Previous work has demonstrated the effectiveness of Triflumuron, and provided information about biological alternatives. More work is needed to improve the effectiveness in farmer fields.

i. **Project Output:** (1) Provide producers with the option to use lower-toxicity pesticides for Andean potato weevil and *Tecia* control (2) Offer a safe and low-cost methodology to control APW and Tecia (3) Identify promising entomopathogenic fungal strains for use against the APW. (4) A better management strategy of Tecia in storage (5) Technical Bulletins and adapted publication on management options and tools for these 2 pests.

j. **Project Impacts:** (1) Farmers will use low cost and low health risk products. (2) Farmers will decrease their production/protection costs 3) Technologies developed will lower the risks of environmental contamination.

k. **Project Start:** September 1998

l. **Project Completion:** September 2004

m. **Project person/months per year:** 10

n. **Project Budget:** USD $ 14,700 (INIAP; includes USD $ 3,700 for CIP Travel); USD $15,396 (Ohio State)

II. 3 Rhizoctonia *solani* Khun and *Streptomyces scabies* in the Crop *Yema de Huevo* (*Solanum Phurejas*): Enhancing Quality and Production for Export

a. **Scientists**: P. J. Oyarzún (INIAP), G. A. Forbes (CIP), D. León, I. Andrade (INIAP), S Sherwood (CIP-FAO), M. Ellis (Ohio State University)

b. **Status:** New activity

c. **Objectives**: **(Overall) –** Develop and apply a specific integrated management strategy for *Rhizoctonia solani* and *Streptomyces scabies* in order to meet increasing demands, in terms of both quantity and quality, for Yema de Huevo. **(Current year) -** Identify sources, acquire and validate biological control agents for preventative seed treatment of Yema de Huevo tubers. Such known agents include *Bacillus thurigens*, *Verticillium bigutatum*. Other approaches such as "bio-remediation" of infested soils will be explored. Specific objectives for the first year include: (1) Organize and maintain *in vitro* a core collection of *Solanum Phureja* with accessions similar to Yema de Huevo. (2)Adapt a greenhouse technique (from literature) for assessment of resistance to these two diseases. (3) Explore commercial sources of potential antagonists or other biological products (bio-remediators). (4) Evaluate efficacy of these products in a field trial (chemicals will be used as controls) to control early season damage and product quality. Healthy and infected seed will be used to determine relative roles of seed-borne and soil-borne inocula. Healthy and infested soils will be evaluated for potential of "bio-remediation". (5) Evaluate three rotation alternatives for reduction of inoculum potential of a naturally infested field. (6) Survey highly infested soils for antagonists that are ecologically fit in Ecuadorian soils. **Some selected objectives for second year**: (1) Conduct a preliminary evaluation (greenhouse technique developed in first year) of levels of disease resistance and tolerance to *R. Solani* and *S. scabies* in the core collection of *S. phureja*. Identify potential progenitors for breeding. (2) Continued field trials of biocontrol products. (3) First participatory on-farm trials of the best products from year one. (4) Repeat rotation study with appropriate modifications. (5) Greenhouse studies using native antagonists.

d. **Hypothesis:** The null hypothesis is that control components (genotypes, antagonists, chemical, and cultural) do not exist. The alternative hypothesis is that these products do exist and that, managed individually or integrated, they are capable of significantly enhancing production and required quality of Yema de Huevo.

e. **Description of research activities**: Known agents for biocontrol, mainly fungi and bacteria, with proven effect on *R. solani* and *S. scabies* will be obtained from American and European research and commercial sources. Additionally, native antagonists will be obtained from roots and parasitized sclerotia of *R. solani* from tubers harvested in pots from soils used repeatedly for potato cultivation. Laboratory and greenhouse experiments will be used to evaluate antagonist activity in natural infested “soils”. Bioremediation based on substances available in the local and international market will be assessed in a similar way. *Field trials*: Three experiments will be installed to: (1) Establish tuber treatment effects on sclerotial development and yield on infested seed in healthy soils with varying levels of infestation on infection, rate of sclerotia development, and yield. (2) Evaluate the effect of bio-remediation on root and tuber infections after infestation of soil with a known amount of inoculum of pathogens. (3) Evaluate inoculum potential of an infested soil after 3 alternative rotations that are appropriate for farmers in the area. Farmer's views and opinions will be encouraged through participation in experiment planning and field days.

f. **Justification:** A new export market for the native potato *Yema de Huevo* has been rapidly expanding over the last few years, with the main import country being the United States. *Yema de Huevo* belongs to the species *S phureja*, which is characterized by excellent taste, color, and culinary qualities. Presently, it is exported after processing and freezing. According to industry, unsatisfied demand is in the order of 300 tons/month. This gap could actually increase, as European countries become more familiar with the product. The current production, in both quantity and quality, has to be considerably increased if Ecuador hopes to keep this market. One of the main factors limiting tuber quality for processing is the attack of tubers by *Rhizoctonia solani* Kuhn and to a lesser degree *Streptomyces scabies*, causing potato black scurf and scab, respectively. Moreover, both pathogens are ubiquitous in the country and are capable of considerable yield decrease after infection of root or stems. As a result of tuber contamination by sclerotia, each tuber has to be inspected and cleaned by hand before processing. As a result of quality control, as much as 50% of the product entering to the processing plant is discarded. To control *Rhizoctonia*, farmers currently use various chemical pesticide products to treat both seed and soil, but results are poor. Furthermore, value for export often depends on reduced-use and even non-use of pesticides. In the US and Europe, multiple effective antagonists of both pathogens have been identified and are being offered commercially. *S. phureja* is an early maturing species with no tuber dormancy. Up to three field cycles a year can be achieved in Ecuador – this greatly facilitates research.

g. **Relationship to other CRSP activities at the site:** This project builds on existing activities of the IPM-CRSP, in particular the activity focusing on improving potato disease management in Ecuador that will end September 2001. In the first year, several activities will take place on the experimental station. In the second and third years, management components will be validated with farmers in participatory research groups (CIALs) presently supported by the CRSP. Special linkages with projects on Biocontrol (M.Sc., Proyecto PROMSA, IASA-CIP-INIAP; PROMSA ESPOCH-INIAP), biodiversity and breeding (Proyecto PAPA, CIP-INIAP) and agronomy (FORTIPAPA) will further strengthen knowledge and component availability for integration of a better disease management strategy.

h. **Progress to date:** This new activity will build on former and on-going research of potato diseases in Ecuador. Presently, the investigators have initiated a core collection of *S. phurejas* with the phenotype of Yema de Huevo and a collection of *Thrichoderma harzianum* is available to start screening for antagonists. Furthermore, INIAP has established ties to industry and farmer organizations throughout the potato producing regions of the country.

i. **Project output:** First year: Simple control components tested mainly based on station research and results available. Second year: Field screening and prospecting completed; initial integration of component strategies; results and procedures documented on a participatory way, made available for extension and technology transfer efforts. The network of Agrofrio growers participate in research and training. Third year: Research activities focus on the validation of integrated strategies and results transferred to farmers beyond pilot groups through farmer field schools and others training activities. A simple handbook for ecological and integrated management of the crop produced with collaborators.

j. **Projected Impacts:** Quality and production: Availability of effective alternative technologies for improving quality and production of Yema de Huevo, enabling producers to decrease reliance on external inputs, lower costs, and improve contractual arrangements with industry for increased sales volumes and commodity price. This research will make production of Yema de Huevo less risky, thus increasing food security. Increased productivity of the crop will reduce poverty. Pesticide reduction would contribute positively to human health and environmental protection.

k. **Projected start:** October 2001

l. **Projected completion:** September 2004

m. **Projected person-months of scientist time:** 12 person-months.

n. **Budget 2001-2002**: USD $ 13,370 (INIAP).

II.4. Developing IPM programs for the main pests of babaco (*Carica heilbornii* var. *pentagona*), naranjilla (*Solanum quitoence*), tree tomato *(Solanum betaceum*) and black berry (*Rubus glaucus*) in Ecuador

a. **Scientists:** Principal investigators**:** J. Ochoa, P. Gallegos, M. Insuasti, J. Revelo, M. Ellis, R. Williams.

b. **Status:** Continuing activity

c. **Objectives: (Overall)** (1) To identify and characterize main pests of four Andean fruit crops. (2) To develop and diffuse IPM control methods. **(Current year)** (1) To study the behavior of the Naranjilla fruit borer (Lepidoptera) to its pheromone. (2) To characterize the effect of nutritional imbalances on babaco mite populations. (3) To develop a biological control method for the babaco mite (*Eothetranichus nr. Deflexus)* using preditors: survey of predatory mite species. (4) To develop a methodology for field application of at least two biocontrol agents for the white grub, *Borotheus castaneus*, which attacks the roots and crowns of Blackberry. (5)To evaluate the resistance to *F. oxysporum,* causal agent of naranjilla vascular wilt, in a collection of different species of the *lasiocarpa* section in the *Solanaceae* family. (6)To characterize the main diseases caused by virus in tree tomato. (7) To study the etiology of “pata de puerco” in tree tomato. (8) To evaluate the agronomic behavior of babaco grafted on rootstocks resistant to *F. oxysporum.* (9) To publish a manual of pests and diseases of babaco, and three scientific articles related to *F. oxysporum* in babaco

d. **Hypotheses**: (1) The Naranjilla fruit borer reacts positively to its pheromone; (2) Nutritional imbalances have significant effects on mite populations; (3) Predatory mites exist and can be effective for babaco mite control; (4) The bioc ontrol agents controlling *Borotheus castaneus* are effective in field conditions; (5) Resistance to *F. oxysporum* is available in the *lasiocarpa* section of the *Solanaceae* family; (6) Viruses cause significant deseases on tree tomato; (7)The "pata de puerco" is caused by a pathogen(s); (8) Babaco plants grafted on rootstocks resistant to *F. oxysporum* have similar agronomic potential to babaco grafted on its own roots

e. **Description of research activity:** The efficiency of pheromone traps for adults of the Naranjilla fruit borer will be evaluated under field conditions. The traps will be placed in the field as the fruit reaches the vulnerable stage in different Naranjilla regions. The number of males moths in the traps will be counted weekly. The number of bore r-damaged fruits will be also assessed to be correlated with the trapped moths.

Mite population development in babaco plants with different levels of chemical fertilization will be evaluated. Plants will be artificially inoculated with the same population of mites. The mite population will be assessed weekly and will be correlated with the nutritional content of the leaves.

A study of predatory mite species will be carried out in native and cultivated *Caricaceae* species in the Tumbaco and Patate valleys. Leaves with phytophagous mites will be collected and carried to the laboratory to analyze the presence of predatory mites. The predatory mites will be conserved in 70% ethylene alcohol and sent to the Ohio State University for taxonomic identification.

Beauveria sp, Metarrhizium sp and two fungal species are being tested for the control of white grubs of blackberry, *Borotheus castaneus.*. The two most efficient treatments will be massively multiplied and tested in commercial plantings.

A collection of the *Lasiocarpa* section of the *Solanaceae* family will be evaluated for resistance to *F. oxysporum* in the green house. One-month-old plants will be inoculated with a suspension of 10^6 conidias/ml. Foliar symptoms will be evaluated using a scale developed in p revious experiments. Fungal colonization and cortical necrosis on the roots and colonization of the plant through the vascular system will also be evaluated. Different isolates of *F. oxysporum* will be utilized.

A series of bioassays will be conducted in o rder to characterize virus diseases in tree tomato. Symptoms will we described in detail in the field and samples will be taken to the laboratory for ELISA tests. Viruses from single and mixed symptoms will be inoculated onto health plants of tree tomato and several indicator plants by means of mechanical inoculation and aphid transmission. Symptom development will be carefully monitored and described. ELISA tests will also be performed on these plants. Combinations of mechanical inoculation, aphids tra nsmission, and symptom development on tree tomato and indicator plants will be used to characterize the viruses.

A series of pathogenicity tests will be carried out in order to identify the causal agent or agents of "pata de puerco". It is possible that a pathogen complex of *Pseudomonas sp*., *Fusarium sp*. and *Meloidogyne* incognita causes the syndrome. Therefore, pathogenicity tests interacting these pathogens will be performed.

The most resistant rootstocks of *F. oxisporum* identified from previous studies will be grafted with babaco and evaluated under commercial conditions. Each rootstock and babaco on its own roots (check) will be evaluated at different plant densities. Agronomic variables such as growth rate, leaf size, fruit yield, fruit weight and nutritional content will be evaluated.

f. **Justification:** Naranjilla vascular wilt caused by *F. oxisporum* and the fruit borer are major constraints to naranjilla production. Naranjilla is regularly grown by small-scale farmers in marginal regions, with basic cultural practices. Under these conditions, chemical control, sanitation and other means of control are of limited value. Plant resistance to *F. oxisporum* and pheremone traps for the fruit borer should be the most practical and economical approaches to control.

Mites are an important babaco pest. It is known that predatory mites hold promise in the control of pest mites. Determination of predatory mite populations and naturally occurring predation are the fist steps to develop biological control for mites in babaco.

Borotheus castaneus is one of the most important constraints to blackberry production in Ecuador. To control this pest, highly toxic compounds are currently being used. Development of biological control methods for *Borotheus castaneus* is highly desirable to reduce the risks from pesticide use.

Virus diseases are a serious threat to tree tomato. To develop control methods, virus identification and their means of transmission must be determined.

"Pata de puerco" has become an important tree tomato disease in several regions of Ecuador. Development of efficient control methods is dependent on proper identification of the pathogen. Characterization of the "pata de puerco" etiology is important.

Babaco is intensively cultivated in greenhouses. Under these conditions, the use of resistant rootstocks to soil borne diseases will significantly reduce losses.

g. **Relationship to other CRSP activities:** These studies are closely related to surveys and research activities conducted in years six, seven and eight. Mite studies are also closely related to previous experiments on low-toxic compounds to reduce mite populations prior to predator release. Biological control of *Borotheus castaneus* is also related to the previous Andean fruit project. Results of "pata de puerco" and grafting studies will be useful for other soil-borne diseases that are being studied in other IPM/CRSP projects. Similarly, studies on virus, bacterial and fungal diseases could be applied to other tropical fruits and in other countries in South America.

h. **Progress to date:** For mite studies, evaluation methods and a scale to assess damage were developed in previous years. For *Borotheus castaneus*, one control alternative was already developed which will be integrated in an IPM program. A survey of major diseases of babaco, naranjilla and tree tomato was conducted in years six, seven and eight. Pathogenicity and pathogen specialization of *F. oxysporum* causing naranjilla vascular wilt has been studied. Some preliminary detection studies of tree tomato viruses using the ELISA test and experiments of yield losses have already been conducted. Fungi and bacteria isolated from "pata de puerco" symptoms are currently being cultured and studied. Manuscripts of scientific arti cles related to *F. oxysporum* in babaco have been written and are being reviewed. Information is available for a manual of pest and disease diagnosis and control on babaco.

i. **Projected outputs:** (1) Traps for the naranjilla fruit borer. (2) Development of a biological control method for the babaco mite with predatory mites. (3) Biological control of the babaco mite will greatly reduce or eliminate pesticide application. (4) Biological control of *Borotheus castaneus* will improve postharvest fruit quality and will also reduce pesticide use. (5) Identification of resistance in the *lasiocarpa* section of the *Solanaceae* family to *F. oxysporum* will improve naranjilla productivity using resistant root stocks. (6) Characterization of virus diseases in tree tomato will allow better planning and control methods. (7) Characterization of the "pata de puerco" etiology will lead to control measures for this disease. (8) A manual of pest and disease diagnosis and control for babaco. Three scientific articles related to *F. Oxysporum* in babaco.

j. **Projected Start:** October 2001

k. **Completion:** September. 2002

l. **Projected Person Months:** 8

m. **Budget October 2001 to September 2002:** USD $ 22,560 (INIAP); USD $ 8,917 (Ohio State).

II.5 Development of IPM Programs for Plan tain Systems in Ecuador

a. **Scientists:** Principal investigators**: C**. Suárez-Capello, D. Vera, C. Triviño – INIAP; R. Williams, M. Ellis – Ohio State University; J. Alwang, G. Norton – Virginia Tech.

b. **Status**: Continuing activity.

c. **Objectives**: **(Overall)** (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 major insects, nematode pests and Black Sigatoka disease on plantain. **(Current year)** (3) Determine economic benefits of implementing IPM components on plantain.

d. **Hypotheses:** (1) Improved agronomic practices help reduce the impact of diseases and pests in plantain monoculture systems in western Ecu ador**;** (2**)** IPM practices help recover productivity of plantain plantations even after a devastating event such as El Niño; (3) the benefits of improved integrated management through IPM practices become evident from the second crop generation; and (4) IPM o n plantain is economically preferred to other management systems.

e. **Description of research activities:** This activity considers: (1) rehabilitation of a plantation – four treatments compare practices in use by farmers (minimum level) with two levels of phytosanitary and crop management practices combined with and without chemicals to control Black Sigatoka, weevils and nematodes. Treatments are combined in a complete-block design with four replications. (2) New establishment of a plantation – in this case, treatments include varieties (2), design of the plantation (2), and levels (2) of management, as main components of an IPM practice. A split plot design with four replications will be used for analysis of data. In both cases, yield per treatment will be related to disease and pest incidence and severity and to the cost/benefit ratio. A comparative analysis of cost benefits on both experiments will test the third and fourth hypotheses.

f. **Justification**: Local farmers derive their way of living mainly from plantain production. The El Carmen area comprises around 45 000 has, producing 30% of national production of nearly 700 000 MT per year. 95% of that is for export to USA, Colombia, Peru, Chile and occasionally to Europe. Opening of international ma rkets increase export demand, which means more and better -quality plantain needs to be produced. Farmers require information decide either to rehabilitate or re -plant their plantation. The CRSP research over three consecutive years will provide the first scientific evidence to support this decision. IPM plantain programs are urgently needed in order to prevent the area from getting into the pesticide culture of bananas due to pressure from pests and diseases.

g. **Relation to other CRSP activities**: This is the only project in the CRSP that deals with plantain. Results, research methods and results from this project will be directly applicable to other activities and projects in Ecuador.

h. **Progress to date:** Harvest of the first generation has shown differences between treatments. Leaf surgery combined with fungicides is showing good efficiency in reducing Black Sigatoka, even when the spraying period is widened to 45 days. The whole IPM practices being applied to these treatments are showing effect on the number, weight and quality of the fruit, making them more suitable for export. 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 insects. Out of 34 insect pest species found, black weevil (*C. sordidus*), striped weevil (*M. hemipterus*), a cottony white fly (*Aleurothrixus floccosus*) mites ("cochinilla"?) (*Dysmicocus brevipes*) and brown scale (*Aspidiotus destructor*) are the main problems. The first one can be considered the most important, not only due to the type and quantity of damage, but because it is present nearly all year round, while the others are more seasonal in nature. From the parasites found, apart from a number of predators, the fungus *M. anisopliae* and *B. bassiana* acting over larvae and adults respectively are those of more potential for the future. As for nematodes, IPM practices (treatments 2 and 3) negatively affect the population of root-damaging nematodes and increases the beneficial ones. Numbers of *Dorilaimus* and *Rabditis* are increasing at significant rates. One thing that should be explored further is the fact that *Radopholus similis*, the most damaging nematode in *Musa* spp is not present in the area of research. Root damage by *Meloidogine* is evident in all treatments, although populations had not reached the threshold levels expected of > 1000 nematodes per cubic centimeter of soil /roots.

i. **Projected outputs**: (1) Understanding of how IPM practices influence pests and disease incidence in plantain: (2) Increased knowledge of the Sigatoka-plantain pathosystem, and the effect of nematodes and weevils on the crop; (3) Determine the biological and cost- effectiveness of cultural (sanitation) and fungicide application on plantain production.

j. **Projected impacts**: The project will develop integrated pest and disease management systems for plantain monoculture. Information to help farmers decide to renovate or rehabilitate an old plantation typical in the area.

k. **Project start:** September 28, 1999

l. **Projected person months:** 12 months

m. **Project completion:** September 28, 2002

n. **Budget:** USD $ 10,670 (INIAP); USD $ 8,596 (Ohio State)

II.6 Introduction of local strains of entomopathogenic fungi to control black weevil in plantain

a. **Scientists:** Principal investigators: Karina Solis, R.Williams, Danilo Vera, and R. Quijije. Colaborative scientists**:** Carmen Suárez, Mike Ellis.

b. **Status:** New activity, but represents a follow up to one conducted during year 8 on the same topic.

c. **Objectives (overall and current year):** (1) To introduce local strains of entomopathogenic fungi from black and striped weevils of plantain, mainly *Beauveria bassiana* & *Metarhizium anisopliae*; and (2) determine their effects on different weevil populations.

d. **Hypothesis**: (1) Local strains of entomopathogenic fungi can be established on plantain as a means of reducing the population of insect pests (*C. sordidus)*; (2) agricultural subproducts such as sugar cane bagasse, molasses, rice straw, grain legumes, are suitable for use as sterile substrate for mass production of entomopathogenic fungi and can be safely obtained and handled by farmers at relatively low cost.

e. **Description of research activity:** Several cultures (strains) of *B. bassiana* and *M. anisopliae* will be tested at the laboratory level for their aggressiveness against *C. sordidus*. Those showing a good competitive capability will be inoculated on highly infested plots. Levels of parasitism/control and population density of insects will be measured at regular intervals. With similar frequencies, attempts will be made to recover the fungi from the insects and the plants. All experiments will use a completely randomized design with 10 to 20 units of observations.

f. **Justification:** Plantain yield is seriously affected by black weevil attack to corms of plants, not only on direct loss due to fall over of severely attacked plants and lost of fruit weight, but indirectly because insects provide easy entrance for bacteria. Although there are no direct figures, it is estimated that as much as half the 60% yield loss of plantain is due to black weevil. There is ample information (confirmed on the activities conducted in this project during the last 2 years) about parasitism of *B. bassiana* and *M. anisopliae* to replace insecticides. However its use has not been spread between farmers because the available commercial formulations are expensive and not always effective, perhaps due to less virulence of the strains in use. Research conducted with IPM-CRSP project in El Carmen, Ecuador has shown that efforts to reduce the black weevil population were ineffective and another strategy should be designed to tackle this component.

g. **Relationship to other CRSP activities.** This activity will provide information and technology to include as part of the IPM program being developed for plantain.

h. **Progress to date:** This new activity will build on previous work on control of weevils in plantain.

i. **Project outputs:** A strategy to control black and striped weevils of plantain and information on effectiveness of strategy.

j. **Project impacts:** (1) Reduction of the use of insecticides and thereby reduction of production cost. (2) Reduction of health risks to farmers and local fauna. (3) Reduction of environmental contamination.

k. **Projected person months**: 6

l. **Project start**: October 2001

m. **Project completion:** September 2003

n. **Budget for 2002:** USD $ 6,820 (INIAP)

II.7 Effect of trapping systems and certain IPM practices on the population dynamics of *Cosmopolites sordidus* (the Banana root borer) on plantain in Ecuador

a. **Scientists: Principal investigators:** R. Quijije; D.Vera (INIAP); R. Williams (Ohio State); **Colaboratiing scientists:** C. Suarez, INIAP; G. Norton (Virginia Tech).

b. **Status:** New Activity. Follow up of others conducted during years 7 and 8 on same component. Due to difficulties with personnel, this activity started late in year 8, so it will continue through year 9.

c. **Objectives (overall and current year):** (1) Determine the effectiveness of different types of traps for *C. sordidus.* (2) Evaluate natural and synthetic attractants as indicators of relative abundance of weevils. (3) Establish appropriate methodology to improve biological and cultural control practices of black weevil in plantain plantations.

d. **Hypotheses:** (1) Traps and attractants exist that can efficiently control black weevil in plantain with minimum risks to farmers and the environment; (2) Population density and dynamics of weevils are determined by environmental factors, management practices and varieties.

e. **Description of research approach:** The effectiveness of four types of traps prepared with plantain pseudostem will be evaluated. Fifteen traps per treatment will be arranged in a completely randomized design within a plantain plantation. Traps will be set out twice a month and will be monitored 48 and 96 hours after trap establishment. In order to determine the population of trapped weevils, 1g of Carbofuran 56 will be applied on each trap. To study population dynamics, a plot of approximately 50 m^2 with at least 200 production units will be set in a plantain plantation. Adult weevils will be trapped, sexed, marked on their elytra with lacquer and released on the same plant. Fluctuation in adult members as estimated using the formula of Jolly and Seber[1] will be related to weather, and seasonal fluctuation. Abundance of black weevil will be analyzed in relation to changes in climatic conditions and the action of natural enemies. Measurements will monitor weather conditions (rain, relative humidity and temperature) during the period. The number of weevils, with and without marks, predators and parasites associated with weevils will be some of the parameters measured in order to determine preferred habitats as well as the time of the year when they predominate.

f. **Justification**: Black weevil is the most economically damaging plantain pest. Although there are no exact figures, it is estimated that 30 % of yield is lost due to this pest. Increasing demand, especially in the study area of El Carmen, pr ompts farmers to use highly dangerous pesticides as Carbofuran to keep *C. sordidus* under control.

g. **Relationship to other CRSP activities:** This activity will provide valuable information to improve IPM practices under development in other CRSP activiti es. This study should answer questions asked by the IPM-plantain project as a way to better define weevil control measures.

h. **Progress to date:** According to results from year 6 in other CRSP activity (IPM Plantain) there are certain differences in the behavior of C. *sordidus* in plantain from that described in the literature. *C. Sordidus* is always associated to *M. hemipterus*, however, the latter does not seem able to cause direct damage to corms, and it appears to be a secondary pest following the tunnels of *C.* sordidus. It appears to favor areas infected with the bacteria *Erwinia* once *C. sordidus* has bored its way through it. *M. hemipterus* is more mobile. It was found 24 m away from the liberation site in 3 days, while the Black weevil took 8 days to cover the same distance. The most important finding relates to the flying distance (25 m for C. *sordidus* and 32 m for *M. hemipterus*) that is three times more than any previous report.

i. **Projected outputs:** (1) More precise life cycle data for *C. sordidus*. (2) A better understanding of the cause of population fluctuation in relation to changes in climatic conditions, phenology of the crop and the action of natural enemies. (3) Low-cost strategies to reduce plantain pests trough the use of natural enemies.

j. **Projected impacts:** Better understanding of the biology and ecology of *C. sordidus* will allow (a) reduced pesticide applications; (b) decreased cost of production and increased profitability of the crop. Less use of pesticides and good quality fruit will permit entrance to more demanding markets.

k. **Project Start**: September 2000

l. **Project Completion**: October 2002

m. **Person months**: 12

n. **Budget for year 9**: USD $ 5,390 (INIAP)

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. **Scientists: Principal investigators**: Carmen Suárez-Capello, Danilo Vera - INIAP; Fernando Echeverría; R. Carroll - University of Georgia; Roger Williams, Mike Ellis - Ohio State University; Wills Flowers - Florida A&M University. **Colaborating Scientists:** Rebecca Justicia, Fundación Maquipucuna; Carmen Triviño - INIAP.

b. **Status:** Continuing activity.

c. **Objectives: (Overall)** Development of an IPM program for crop management in the fragile subtropical ecosystem of the Andean slopes. **(Current year)** (1) Develop basic information on the incidence of aerial plant pathogens, mainly *M. Fijensis*, the causal agent of black sigatoka disease, in monoculture plantain plantations, and in a polyculture agro-forestry system. (2) Determine incidence, seasonally and relative abundance of pests and diseases within six different crop systems on the Andean North Occidental slopes. (3) Determine the effect of bagasse and ash amendments to root-damaging and predator nematode populations. (4) Study the life cycle and ecological requirements of *Castniomera humboltii* (Castniidae, Lepidoptera), a destructive pest of plantain in Northwest Ecuador. (5) Develop basic information about impacts of pest management practices on populations of pests in an Agro-forestry system.

d. **Hypotheses:** (**Overall**) (1) Integrated pest and disease management are the best alternatives for sustainable production in fragile environments; (2) Identification of major problems in Andean subtropical cropping/cropping systems will facilitate development of IPM management strategies for farmers on fragile ecosystems subject to increasing colonization pressure. (**Current year**) (1) Polyculture cropping will show fewer incidences of pests and diseases (especially root-damaging nematodes) than monoculture plantations. (2) Bagasse and ash 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. (3) Determination of environmental effects of Andean subtropical agro forestry/cropping systems will facilitate development of IPM management strategies for farmers on fragile ecosystems subject to increasing colonization pressure.

e. **Description of research activity:** Plots have been established at MAQUIPUCUNA using the following crops: Maqueño plantain, coffee and lemon. Plots consist of single crops or combinations of the three crops. There are three replications of each crop combination. Plots will be monitored in monthly intervals for the presence of insects, mites and symptoms of disease. Tissue samples from apparently diseased plants will be collected and processed on media at Pichilingue laboratories to determine the presence of plant pathogens and vascular wilts. A survey of selected elements of the insect communities, focused on actual and potential pests as well as parasitoid and predator guilds, has been initiated. Pests are being hand-collected; sweeping crop plants and yellow pan trapping collects parasitoid and predator guilds. Traps are placed to capture possible variation in the insect communities due to the different combinations of crop plantings. Collections of larval and pupae material of *C. humbolti* have been completed, and observations of the tunneling behavior of mature larvae in plantain trunks is underway. In the coming dry season, studies of adult feeding and egg laying behavior will be performed, and we will attempt to use sugarcane bagasse as bait for the adult moths. Studies of egg parasitism will also take place; based on research on a related species in Peru, we have reason to believe that egg parasitoids will be a method of biological control of this pest.

The established plots of each cropping system will be managed uniformly with minimal use of chemical pesticides. All other agronomic best management practices (BMPs) will be applied. Soil and root sampling and corresponding processing will be conducted to determine nematode type and population within each system. Basic meteorological equipment will be set near the cropping system at Orongo to monitor weather (rain, relative humidity and temperature) conditions throughout the year. Simultaneous data will be collected from a nearby meteorological station for future comparison and analysis. These weather conditions will then be related to pest and diseases present during the same time.

Weeds will be selected in agreement with what local farmers regard as particularly difficult. Grasses and nut sedges will be monitored. They will be preserved dried and pressed in vouchers for future identification. Another area will be measured for all weeds, and each problem weed will be detected. To determine the relative cover area, a 0.5 square meter PVC sampling frame will be designed. The frame will be divided into a grid of 10X10 cm squares, using string. The sampling frame will be down on randomly chosen locations in different treatments. Then the weeds that occur at each of the 16 intersections on the grids will be recorded. Only one plant in each intersection will be recorded and converted to percentages.

The survey of pests and natural enemies will be a baseline to direct subsequent specific studies of the use of individual species in biological control; subsequent monitoring of pests and their enemies will provide a measure of the impact of both cropping systems and applied practices may produce on the intervened area.

f. **Justification:** This highly vulnerable Andean region requires production systems that simultaneously offer an economic activity to farmers and minimize 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; few attempts have been made to find alternative uses for them. Farmers do not have many productive alternatives in the area. Farmers now have a mixture of coffee, "Banana", citrus and a low-quality pasture, Setaria. Coffee, banana and citrus are scattered in farms with high mortality within orchards caused by pest and diseases. The region may produce good-quality coffee and citrus. The potential for this agro-forestry system is good, provided farmers can solve their ecological (mainly soil erosion) and phytosanitary constraints. The survey of pests and natural enemies will provide a baseline to direct subsequent specific studies of the use of individual species in biological control. Additionally, it will give managers of conservation areas information on insect interactions in protected forests and neighboring agroscapes. The study of the life cycle of *C. humbolti* in MAQUIPUCUNA will be directly applicable to the coastal area of Esmeraldas where this moth is also a serious pest.

g. **Relationship to other CRSP activities.** Any information on the type and relative abundance of pest and disease of this 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 on with this project, especially that concerned to black Sigatoka disease and main insect pests of plantain.

h. **Progress to date:** Within the Orongo farm, an area of 5900 m^2 has been planted with an ordered system including crops that are common in the region: plantain (Maqueño variety), coffee and citrus. Lemon trees of the Meyer variety were used. Maqueño will be for local market but coffee and lemon are used for export. The agro forestry design consists of 4 blocks each with 6 treatments: (1) Single rows plantain + coffee; (2) Double rows of plantain + coffee; (3) plantain + citrus; (4) plantain lone; (5) coffee; (6) citrus. Each block has 1114 m^2 with treatments plots of 120 m^2. Two Malaise traps have been located in the agro-forestry plots and will be activated four times a year to get periodic snapshots of the general insect fauna of the project area. Initial trials of yellow pan traps have demonstrated the usefulness of this method of trapping. As noted above, specimens and observations on the immature stages of *C. humbolti* have been collected.

i. **Projected outputs:** (1) A better understanding of the incidence of root-damaging pest and diseases in polyculture agro forestry. (2) First-hand information about incidence, seasonality and severity of phytosanitary constraints for three important crops within an agro-forestry system design suitable for sustainable agricultural usage. This information will serve as a baseline to validate IPM practices on these systems. (3) Knowledge of the effects of using sugarcane bagasse on behavior of *Castiomera*. (4) Knowledge of the occurrence and behavior of predators and parasites of nematodes and insect pests.

j. **Projected impacts:** (1) Valuable information about the relative importance of pest and diseases of plantain, coffee and citrus agro forestry, allowing a prioritization of future work in the region. (2) Low-cost strategies to reduce the main plantain pests. Improved incentives for converting low-quality pasture to stable agro forestry in fragile environments like the Andean slopes. (3) A strategy to utilize sugarcane byproducts to improve agro-forestry production.

k. **Project start:** October 31, 2000

l. **Project completion**: September 1, 2004

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

n. **Budget:** USD$ 15,510 (INIAP); USD$ 7,040 (Georgia); USD$ 6,237 (Florida A&M)

III. Socioeconomics

III.1. Modeling Impacts of Changes in Pest Management Technologies (joint researc h activity with the SOIL MANAGEMENT CRSP)

a. **Scientists:** P. Espinosa, L. Escudero – CIP; V. Barrera, G. Suquillo – INIAP; J. Antle – Montana State (Soil Management CRSP); S. Wood and P. Pardey – IFPRI; 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 aggregate economic impacts of the IPM technologies developed on the IPM CRSP, including spillovers across regional and national boundaries. **(Current year)** Write up results of Year 8 potato impact assessments, from both objectives above, for journal publication. Initiate impact assessment for the plantain IPM on the coast.

d. **Hypotheses:** (1) Land use and management, farmer income, and pesticide use will not be affected by IPM technologies generated on the IPM CRSP; and, (2) IPM CRSP technologies do not have economic impacts or spillovers.

e. **Description of research activity:** A bio-economic simulation model was used in year 8 to address objective one, a part of the collaboration with the Soils CRSP, to explore the effects of factors such as changes in technologies and prices on land use and management, revenues, income stability, erosi on, contamination of water tables, etc. This model was developed for the same geographic region where the potato IPM work is underway on the IPM CRSP. Changes in pesticide use as a result of IPM were fed into the model as a scenario. The results of that work will be written up in year 9. 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 sur plus 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. In year 8, the data were analyzed as part of an undergraduate thesis for the potato experiments in Carchi. In year 9, the data from the plantain experiments on the Coast will be analyzed. 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 within the household. Application of the models developed at this site may provide a template for subsequent joint research activities in other sites as well. It also provides the first attempt to estimate profitability of plantain IPM.

g. **Relation to other research activities at the site:** This project directly complements other research activities underway on the SOILS CRSP on bio-economic modeling and at CIP and INIAP in general and on the IPM CRSP in particular to control late blight, Andean potato weevil, and potato tuber moth.

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 colla boration 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 l evel 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 will be written up for publication this year while the new analysis of plantain IPM impacts is begun.

i. **Projected outputs:** The activity will produce both models and reports that describe impacts of the IPM research on potatoes 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**: USD $7,810 (INIAP); USD $13,335 (Virginia Tech)

III.2 Intrahousehold Resource Dynamics and Adoption of Pest Management Practices.

a. **Scientists: Principal investigators**: Colette Harris (Virginia Tech.); Danilo Vera, Victor Barrera, Jovanny Suquillo, María Crizón, Luis Escudero (INIAP). **Collaborating scientists**: Carmen Suárez (INIAP); George Norton, Jeff Alwang (Virginia Tech), Stephen Sherwood (CIP Quito).

b. **Status**: Continuing Activity

c. **Objectives**: **(Overall)** (1) To identify social and economic factors influencing pest management practices at the household and intrahousehold levels and to examine social, economic, and health impacts of current management practices at the community, household and intrahousehold levels in the coastal area of plantain cultivation. (2) To identify constraints on the likely adoption of IPM strategies. (3) To support activities and inter-institutional relationships that will improve the status of women, and encourage changes in attitudes about pests and their management. (4) To train research scientists involved with the IPM-CRSP project in Ecuador in socio-gendered action research methodology. **(Current year)** (1) To identify constraints on the likely adoption of IPM strategies in the coastal region. (2) To support activities and inter-institutional relationships that will improve the status of women, and encourage changes in attitudes about pests and their management in the villagers and their families involved in the Carchi Farmer Field Schools. (3) To train research scientists involved with the IPM-CRSP project in Ecuador in socio-gendered action research methodology.

d. **Hypothesis**: Working at community level within a gendered framewor k will produce fundamental changes in attitudes about pests and their management that will facilitate the adoption of IPM practices, improve family relationships and the social status of women.

e. **Description of research activity**: A base-line survey will be conducted in the plantain area to obtain a quantitative and qualitative picture of the family approach to crop management. A questionnaire will be designed and applied to some 150 farms/families within the plantain area. Families will be chosen from a t least three different levels of organization (individual farmers or members of cooperatives) and crop management (low or medium levels of technology usage). Two social scientists will be trained for the survey. In the second phase, a small number of tho se farms/families already surveyed will be selected for in -depth qualitative study of their pesticide management strategies for plantain and other related socio -economic factors. Focus-groups will be organized in the Carchi area This activity will feed in to the farmer field schools run by UVTT Carchi/INIAP, teaching IPM strategies (see research activity III.3). The farmers involved in these schools, their family members, and other relevant community members will be included in focus -group discussions round such themes as preventative strategies for health and the protection of the environment, the subjects for these discussions to be chosen by the participants themselves. Collaboration with other institutions, such as local NGO's will facilitate this work, especially in the area of improved economic status for women. At least four facilitators (both men and women) will be trained to carry out this activity.

f. **Justification:** (1) Research results on plantain in the El Carmen area demonstrate the possibility of effecting substantial improvement to both quantity and quality of the fruit produced with the adoption of some relatively simple new farming techniques. The surveys carried out on attitudes and practices within the family will help future targeting of outreach work to bring this information to the community, thus saving time and effort. Gender analysis may also provide information about new approaches to research as well as about constraints that so far have been overlooked. (2) A major constraint that has been identified which prevents the adoption of IPM practices in Carchi is the lack of attention rural men and women pay to their own health and that of their families. Changing their attitudes to think about preventative measures for health should a) help them to realize the consequences of using large quantities of pesticides for their own health and b) take a different attitude to the use of chemicals.

g. **Relationship to other CRSP activities**: This project directly complements both the agronomical research being carried out in the coastal plantain areas and the farmer field school activities in the Sierra.

h. **Progress to date**: Base-line data was collected for Carchi and has been analyzed. However, so far none has been collected for the coastal area. The qualitative activities are new in year 9.

i. **Projected outputs**: (1) Compilation of data, a report presenting descriptive statistical analysis testing hypotheses concerning pest management practices and other socio-economic in the coastal plantain growing area, and a report presenting a description of farming practices and attitudes of the small segment of plantain growers involved in the qualitative survey. (2) Two trained researchers in integrated socio-gendered research in the coastal area. (3) Four trained facilitators for focus-group discussions in the Carchi area. (4) Groups of villagers with changed attitudes towards their health and the environment in Carchi. (5) At least one scientific paper on farming practices and attitudes in the plantain-growing area.

j. **Projected impacts:** Increased adoption of IPM and more egalitarian distribution of economic and health benefits of IPM among farm family members. Less damage to the environment. Improved health status and higher status for women in the families involved in the Carchi area.

k. **Project start**: October 1st, 1999

l. **Project completion**: September 29th, 2002

m. **Projected person-month of scientist time**: 24 months of researcher time in the plantain area; 48 months of facilitator time in Carchi. Three months of PI time in Ecuador

n. **Budget for year 9:** USD $ 6,930 (INIAP), USD $9,208 (Virginia Tech)

III.3 Validation and Diffusion of Models for Integrated Pest Management (IPM) of Potato in the Carchi and Bolívar, Ecuador.

a. **Scientist(s) Names and Institutional Affiliations:** Víctor Hugo Barrera (INIAP-E.E. Santa Catalina), Luis Escudero (IPM-CRSP-Carchi), Jovanny Suquillo (INIAP-Carchi), Jorge Revelo (INIAP-E.E. Santa Catalina), Patricio Gallegos (INIAP-E.E. Santa Catalina), Stephen Sherwood (CIP-Estación Quito), George Norton (IPM-CRSP Virginia Tech), Jeff Alwang (IPM-CRSP Virginia Tech), Colette Harris (IPM-CRSP Virginia Tech)

b. **Status:** Continuing activity.

c. **Objectives (overall and current year):** (1) To validate and diffuse models of integrated pest management of potato in communities in Carchi and Bolívar. (2) To incorporate integrated management components generated on the different projects of development of alternatives for integrated pest mangement of potato in Ecuador.

d. **Hypothesis:**Integrated pest management models for potatoes are adequate for production systems in Carchi and Bolívar.

e. **Description of activities:** INIAP, through the Validation and Transfer Units of Carchi and Bolívar, with the support of the Nucleus of Technical Support and Training and the Plant Protection Department of Santa Catalina Experimental Station of INIAP, and the International Potato Center, during the last two years, have consolidated their experience on Validation and Diffusion of technologies of Integrated Management of the main Pests and Diseases of Potato (IPM). Based on this experience using the Field Schools (FS) approach, we expect to transfer knowledge to farmers through participatory training and validation and diffusion of IPM models. The planned activities for this study are: location, diagnosis, organization, implementation, following and evaluation of 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 activities being performed and those that will be implemented in Carchi and Bolívar provinces, with the support of IPM-CRSP and other projects as well.

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. Sixty three training sessions were performed and seventy two potato farmers got trained and graduated. Two field days were held with the 450 participants. Interchange field trips among farmers of the region and of the Field Schools were conducted, in order to share experiences.

The results show promise in the control of the main potato pests. For instance, at the IPM plot planted with the Superchola variety, the control number was reduced to only 7 during the whole crop cycle, whereas on the conventional plot 12 applications were needed. Using the late blight resistant INIAP-Fripapa variety, the controls (7) were higher than those needed at the Field Schools plots (4). The Field Schools farmers participants were able to see the profitability differences between the two management systems. All of the above has demonstrated the comparative advantages of the use of the IPM components on potato crop.

The Field Schools sponsored by the IPM-CRSP project have created interest from other institutions, national as well as international ones. The Food and Agricultural Organization (FAO) of the United Nations is supporting the implementation of 6 Field Schools at the Carchi province and 1 at Bolívar province. A course on training the trainers on potato crop production and IPM is planned. This training activity will last for 8 months and will be facilitated by technical personnel of INIAP, MAG and the IPM-CRSP.

i. **Projected Outputs:** Models of Integrated Pests and Diseases Management mated to the agro-social-economic conditions of the potato farmers in Carchi and Bolívar. A strategy for training and diffusion of Integrated Pest and Disease Management models.

j. **Projected Impacts:** (1) Reduction of pesticide purchases. (2) Reduction of health risks for farmers and consumers. (3) Improved environmental protection due to the reduced use of pesticides.

k. **Projected Start:** October 2000.

l. **Projected Completion:** September 2003.

m. **Projected Person-Months of Scientists Time per Year:** Chief investigator, 8 months; agricultural investigators, 8 months; field technicians 12 months.

n. **Budget October 2001-September 2002**: USD $ 20,000

SUMMARY OF RESEARCH ACTIVITIES - YEAR 9 WORKPLAN FOR SOUTH AMERICAN SITE IN ECUADOR
(September 30, 2001 – September 29, 2002)

ACTIVITY	SCIENTISTS	BUDGET ($)
Pest Monitoring and Diagnosis		
I.1 Survey of the incidence and economic importance of nematodes in Plantain	Principal investigators - Randy Rivera, C. Suárez, C. Triviño; Collaborative scientists: Mike Ellis (Ohio State), Danilo Vera.	USD $4,625 (INIAP)
Development of IPM Practice		
II.1 Development of late blight management strategies for resistant potato cultivars in Ecuador: Not Funded II.2 Development of Biocontrol methods for two major potato pests in Ecuador: The Andean Potato Weevil, *Premnoptrypes vorax*, and the Central American tuber moth, *Tecia solanivora*	Patricio Gallegos, César Asaquibay, Sandra Garcés, Geovanny Suquillo INIAP, Aziz Lagnaoui (CIP) and Roger Williams, Ohio State University	USD $14,700 (INIAP; includes USD $3,700 for CIP Travel); USD $15,396 (Ohio State)
II.3 Rhizoctonia *solani* Khun and *Streptomyces scabies* in the Crop *Yema de Huevo* (*Solanum Phurejas*): Enhancing Quality and Production for Export	P. J. Oyarzún (INIAP), G. A. Forbes (CIP), D. León, I. Andrade (INIAP), S Sherwood (CIP-FAO), M. Ellis (Ohio State University)	USD $13,370 (INIAP)
II.4 Developing IPM programs for the main pests of babaco (*Carica heilbornii* var. *pentagona*), naranjilla (*Solanum quitoence*), tree tomato *(Solanum betaceum*) and black berry (*Rubus glaucus*) in Ecuador	Principal investigators**:** J. Ochoa, P. Gallegos, M. Insuasti, J. Revelo, M. Ellis, R. Williams.	USD $22,560 (INIAP); USD $8,917 (Ohio State)
II.5 Development of IPM Programs for Plantain Systems in Ecuador	Principal investigators**: C**. Suárez-Capello, D. Vera, C. Triviño – INIAP; R. Williams, M. Ellis – Ohio State University; J. Alwang, G. Norton – Virginia Tech	USD $10,670 (INIAP); USD $8,596 (Ohio State)
II.6 Introduction of local strains of entomopathogenic fungi to	Principal investigators: Karina Solis, R.Williams, Danilo Vera,	USD $6,820 (INIAP)

control black weevil in plantain	and R. Quijije. Colaborative scientists: Carmen Suárez, Mike Ellis	
II.7 Effect of trapping systems and certain IPM practices on the population dynamics of *Cosmopolites sordidus* (the Banana root borer) on plantain in Ecuador	Principal investigators: R. Quijije; D.Vera (INIAP); R. Williams (Ohio State); Colaboratiing scientists: C. Suarez, INIAP; G. Norton (Virginia Tech).	USD $5,390 (INIAP)
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	Principal investigators: Carmen Suárez-Capello, Danilo Vera - INIAP; Fernando Echeverría; R. Carroll - University of Georgia; Roger Williams, Mike Ellis - Ohio State University; Wills Flowers - Florida A&M University. Colaborating Scientists: Rebecca Justicia, Fundación Maquipucuna; Carmen Triviño - INIAP	USD $15,510 (INIAP); USD $7,040 (Georgia); USD $6,237 (Florida A&M)
Socioeconomics		
III.1 Modeling Impacts of Changes in Pest Management Technologies (joint research activity with the SOIL MANAGEMENT CRSP)	P. Espinosa, L. Escudero – CIP; V. Barrera, G. Suquillo – INIAP; J. Antle – Montana State (Soil Management CRSP); S. Wood and P. Pardey – IFPRI; J. Alwang and G. Norton – Virginia Tech.	USD $7,810 (INIAP); USD $13,335 (Virginia Tech)
III.2 Intrahousehold Resource Dynamics and Adoption of Pest Management Practices	Principal investigators: Colette Harris (Virginia Tech.); Danilo Vera, Victor Barrera, Jovanny Suquillo, María Crizón, Luis Escudero (INIAP). Collaborating scientists: Carmen Suárez (INIAP); George Norton, Jeff Alwang (Virginia Tech), Stephen Sherwood (CIP Quito)	USD $6,930 (INIAP), USD $9,208 (Virginia Tech)

III.3	Validation and Diffusion of Models for Integrated Pest Management (IPM) of Potato in the Carchi and Bolívar, Ecuador	Víctor Hugo Barrera (INIAP-E.E. Santa Catalina), Luis Escudero (IPM-CRSP-Carchi), Jovanny Suquillo (INIAP-Carchi), Jorge Revelo (INIAP-E.E. Santa Catalina), Patricio Gallegos (INIAP-E.E. Santa Catalina), Stephen Sherwood (CIP-Estación Quito), George Norton (IPM-CRSP Virginia Tech), Jeff Alwang (IPM-CRSP Virginia Tech), Colette Harris (IPM-CRSP Virginia Tech)	USD $20,000

Ninth Year Work Plan for the Eastern European Site in Albania

IPM CRSP research activities in Albania will be initiated in year seven 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 Meeting the educational and planning needs for Olive Integrated Pest Management

a. Scientists: Charlie Pitts, Greg Luther, Keith M. Moore, Doug Pfeiffer, Lefter Daku, Beth Teviotdale, Louise Ferguson, Milt McGiffen, Fadil Thomaj, Myzejen Hasani, Rexhep Uka, Magdalena Bregasi, Enver Isufi, Brunilda Stamo, Harallamb Pace, Josef Tedeschini, Hajri Ismaili, Mendim Baci, Zaim Veshi, Dhimiter Panajoti, Bardhosh Feraj, Shpresa Çali

b. Status: Finishing second year

c. Objectives: To (1) provide educational opportunities for Albanian and American cooperators in biological and statistical aspects of olive pest management system, (2) provide opportunity to meet to plan forthcoming CRSP activities, 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 male and female 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.

f. Justification: The need for close collaboration among Albanian and American counterparts continues, to facilitate planning of research. Now that research is underway, the time is opportune to begin grower education efforts to (1) improve grower expertise, and (2) increase visibility of our scientists in order to increase eventual grower adoption of results of CRSP activity. Quality of research will be enhanced through statistical training. 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: In the first year of implementation, the Baseline Survey was completed, and a statistical short course was carried out in Tirana. Initial discussions have taken place with AAATA (Assistance to Albanian Agricultural Trade Associations) and the AOA (Alimentary Oils Association on the prospects of sharing the program of upcoming training sessions, as well as production of extension publications . A second statistics workshop was held in the second year (Spring 2001), and in May 2001 a grower workshop was held in Dhermi.

i. **Projected outputs:** Detailed research plans will be produced. Higher quality publications will be produced. Grower training wi ll gain a foothold.

j. **Project impacts:** Understanding by American participants of Albanian olives and research situation will be enhanced. Expertise in biological control of both Albanian and American participants will be increased. The Albanian researc hers 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:** $23758 - Albanian institutions; $14066 - Penn State; $0 - University of California; $2921 - Virginia Tech

I.2 Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems

a. **Scientists:** F. Thomaj, M. Bregasi, J. Tedeschini, H. Ismaili, Z. Veshi, M. Baci, H. Pace, R. Uka, M. Hasani, E. Isufi, B. Stamo, V. Jovani (nematologist), Sh. Shahini, B. Huqi – Albanian institutions; C. Pitts – Penn State; L. Ferguson, B. Teviotdale, M. McGiffen – University of California; D. Pfeiffer – Virginia Tech

b. **Status:** Finishing second year

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 olive production systems (2) Weed species and growth pattern are affected by the vegetable cropping system.

e. **Description of research activity:** Monitoring will be carried out in farmers' olive groves. There will be one key site (Vlora). Monitoring of insect pests, disea ses and nematodes will be carried out intensively at the key site. Insect pests and natural enemy populations will be monitored by direct counts/sweet-net sampling /vacuuming /pitfall traps/ water pan traps/ pheromone traps, etc. Representative groves olives will be chosen in Vlora. Within each grove, trees will be randomly chosen. Pest and crop damage will be monitored on these trees. For leaf-feeding insects, select three tips or leaflets. Count all insects on these samples and record the total number of leaves. For fruit feeding insects, select representative fruit from each sample tree and count all pest insects. Rate each of the selected trees for disease incidence and other damage concurrent with insect evaluations. For passive sampling techniques (Pa n Traps, Pit Fall Traps, etc.), 6 devices will be placed in each field. Traps will be emptied and preservative replaced after each evaluation.

Parasitism rates will be determined by collection of eggs, larvae and pupae and reared in the laboratory. Crop damages will be estimated by direct counts or by using a scoring scale. Abundance of diseases will be monitored using appropriate scoring scales. Incidence and abundance of nematodes, root diseases and insect damages will be monitored by sampling under t he tree. Randomly selected trees will be 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:** Documenting the pests and natural enemies in olive groves. 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 fo r solving pest problems in rice -vegetable 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 p atterns in a particular crop.

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:** 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 e xperimental 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:** $ 11258 - Albanian institutions; $ 0 - Penn State; $ 0 - University of California; $ 254 - 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 – Albanian institutions; L. Ferguson – University of California; C. Pitts – Penn State.

b. **Status:** Finishing second year

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 will be selected at Vlora experimental orchards. This will be divided into 5, (I -V) blocks. Within each block 35 uniform trees will be selected and using a random number table 5 sub -samples will be 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.

g. **Progress to date**: Work on this project was initiated in spr ing, 2000. Orchard blocks have been cultivated and pruned at Shamogjin, a research grove near Vlora operated by Fruit Tree Research Institute. The optimal harvest time for the Frantoi cultivar, as shown in preliminary results from 2000 may be the last of October.

h. **Projected outputs:** Improved IPM management of Olives.

i. **Projected impacts:** Increased net returns and decreased use of pesticides.

j. **Projected start:** September 1999

k. **Projected completion:** September 2002

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

m. **Budget:** $ 23830 - Albanian institutions; $ 0 - Penn State; $ 2600 - University of California; $ 127 - Virginia Tech

II.2 Vegetation Management

a. **Scientists:** H. Ismaili, J. Tedeschini, D. Panajoti, B. Stamo, H. Pace, B. Huqi, R. Uka – Albanian institutions; M. McGiffen and L. Ferguson Univ. of California

b. **Status:** Finishing second year

c. **Objectives:** Determine the effect of vegetation management on pest populations and yield.

d. **Hypotheses:** (1) Vegetation management affects pest populations and olive yield; (2) Organic olive production can be profitable for Albanian farmers.

e. **Description of research activity**: A randomized complete block experiment will be set up in two fields, an organic production system, and one using synthe tic pesticides and fertilizers. Each treatment will be replicated five times. The seven conventional treatments will 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 will be used for the conventional production field. The organic field will have five of the above treatments, and will not include the two herbicide treatments. Copper sulfate and Bordeaux Mix will be used for pathogen control in the organic field; organic insect control will use BT and pheromone disruption. The following parameters will be 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. There is a rapidly growing market for organic products such as organic olive oil and table olives. Organic products command prices several times higher than for the conventional segment of the 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. Relationship to other research activities at the site: These experiments are only indirectly related to other activities. Most of this CRSP's activities in Albania will be conducted at this site. The knowledge gained will aid all pest management disciplines.

g. **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.

h. **Projected outputs:** Refereed publications from both the field and greenhouse experiments. Growers will gain new information on vegetation management and organic production.

i. **Projected impacts:** New systems for weed management. Reduced disease and insect populations. New herbicides for olives. Development of new products, organic olives and oil, for the export market

j. **Project start:** October 1999

k. **Projected completion:** November 2002

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

m. **Budget:** $ 11758 - Albanian institutions; $ 2600 - University of California

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

a. **Scientists**: Z. Veshi, J. Tedeschini, M. Baci, H. Pace, R. Uka, M. Hasani and E. Isufi – Albanian institutions; D. Pfeiffer – Virginia Tech; L. Ferguson, B. Teviotdal e – University of California

b. **Status:** Finishing second year

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) will be tested. Trees will be pruned once and treatments will be applied in January and February. Production of fruiting wood will be assessed after six months, one and two years. 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. Olive knot will be assessed by determining the number of infected pruning cuts that became infected. Spray penetration will be assessed by determining scale mortality after a pesticide application. Water sensitive paper will be attached to branches and the density of water droplets will be quantified. Using other trees, copper sprays will be applied monthly from October through May. Immediately before application, 30 leaves will be collected at random from each tree and tested for latent infections of olive leaf spot. Also, ten pairs of leaves will be removed. Twenty 1-yr-old shoots per tree and 20, 2.5 cm diameter shoots will be pruned. Natural incidence of olive leaf spot will be 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 will be 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.

g. **Relationship to other research activities at the site**: Other research activity on olive growth and insect development will be carried out at Vlore. This is a site with capable support staff to help with this project. There are also good experimental conditions for this project.

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.

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:** $ 10258 - Albanian institutions; $ 2600 - University of California;

$ 127 - Virginia Tech

II.4 Pheromone-Based IPM in Olive and Effects on Non-Target Species

a. **Scientists**: R. Uka, E. Isufi, J. Tedeschini, M. Baci, S. Çali – Albanian institutions; D. Pfeiffer – Virginia Tech

b. **Status:** Finishing second year .

c. **Objective:** To develop a selective attractant-based control system for olive fruit fly, *Bactrocera (Dacus) oleae* (Gmelin), an d document its suitability for black scale, *Saisettia oleae* Olivier, biological control.

d. **Hypotheses:** (1) Pheromone dispensers and food traps will provide effective control of olive fruit fly; (2) A minimum block size of 2 ha is required; (3) The pherom one-based program will allow successful biological control of black scale.

e. **Description of research activity:** Mass trapping will be used for olive fruit fly. Traps 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: (1) pheromone-based, (2) insecticide, and (3) untreated control. A trial will be continued in an isolated grove, and another in a block near other untreated trees, more closely reflecting most grower conditions.

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. Funding is included here to support an Albanian scientist in pursuit of a Ph.D. program at Virginia Tech; it is expected that field research will focus on this project.

g. **Relationship to other research activities:** Vlora is the site of focus for all the research activities in the IPM CRSP. Concurrent data will be collected on these species to enhance our understanding of pest and tree biology.

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 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. 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 %.

k. **Starting date:** 1 October 1999

l. **Ending date**: 31 September 2002

m. **Scientist-months per year:** 10

n. **Budget:** $ 14758 - Albanian institutions; $ 25207 - Virginia Tech

III. Socioeconomic analyses

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:** Finishing second year

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:** 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:** $ 6258 – Albanian institutions; $7620 – Virginia Tech

SUMMARY OF RESEARCH ACTIVITIES - NINTH YEAR WORK PLAN FOR THE ALBANIAN SITE
(September 30, 2001 – September 29, 2002)

ACTIVITY	SCIENTISTS	BUDGET ($)
Baseline Survey and Crop/Pest Monitoring		
I.1 Meeting the educational and planning needs for Olive Integrated Pest Management	Charlie Pitts, Greg Luther, Keith M. Moore, Doug Pfeiffer, Lefter Daku, Beth Teviotdale, Louise Ferguson, Milt McGiffen, Fadil Thomaj, Myzejen Hasani, Rexhep Uka, Magdalena Bregasi, Enver Isufi, Brunilda Stamo, Harallamb Pace, Josef Tedeschini, Hajri Ismaili, Mendim Baci, Zaim Veshi, Dhimiter Panajoti, Bardhosh Feraj, Shpresa Çali	$23,758 - Albanian institutions; $14,066 - Penn State; $0 - University of California; $2,921 - Virginia Tech
I.2 Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems	F. Thomaj, M. Bregasi, J. Tedeschini, H. Ismaili, Z. Veshi, M. Baci, H. Pace, R. Uka, M. Hasani, E. Isufi, B. Stamo, V. Jovani (nematologist), Sh. Shahini, B. Huqi – Albanian institutions; C. Pitts – Penn State; L. Ferguson, B. Teviotdale, M. McGiffen – University of California; D. Pfeiffer – Virginia Tech	$11,258 - Albanian institutions; $0 - Penn State; $0 - University of California; $254 - Virginia Tech
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 – Albanian institutions; L. Ferguson – University of California; C. Pitts – Penn State	$23,830 - Albanian institutions; $0 - Penn State; $2,600 - University of California; $127 - Virginia Tech
II.2 Vegetation Management	H. Ismaili, J. Tedeschini, D. Panajoti, B. Stamo, H. Pace, B. Huqi, R. Uka – Albanian institutions; M. McGiffen and L. Ferguson Univ. of California	$11,758 - Albanian institutions; $2,600 - University of California
II.3 Effect of pruning on olive production, infestation by	Z. Veshi, J. Tedeschini, M. Baci, H. Pace, R. Uka, M. Hasani and E. Isufi –	$10,258 - Albanian

	black scale and incidence of olive knot and timing of copper sprays to control olive leaf spot and olive knot	Albanian institutions; D. Pfeiffer – Virginia Tech ; L. Ferguson, B. Teviotdale – University of California	institutions; $2,600 - University of California; $127 - Virginia Tech
II.4	Pheromone-Based IPM in Olive and Effects on Non-Target Species	R. Uka, E. Isufi, J. Tedeschini, M. Baci, S. Çali – Albanian institutions; D. Pfeiffer – Virginia Tech	$14,758 - Albanian institutions; $25,207 - Virginia Tech
Socioeconomic analyses			
III.2	Project Economic Impacts of Albania IPM CRSP Research Activities	L. Daku (Albanian graduate student and faculty member at AUT), M. Bregasi, D. Taylor and G. Norton – Virginia Tech	$ 6,258 – Albanian institutions; $7,620 – Virginia Tech

Degree Training

Integrated Pest Management
Collaborative Research Support Program
(IPM CRSP)

Annual Workplan
For Ninth Year
(September 29, 2001 to September 28, 2002)

Appendix Table 1. IPM CRSP Student Training Participants in Year 9 (Sep. 29, 2001 - Sep. 28, 2002)

Latin America Region

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	Guatemala	M.S.	Aug. 00	Sep. 02	100%	S. Weller		
2	James Julian	M	USA	Marketing	Central America	Ph.D.	Jul. 95	Jun. 02	100%	G. Sullivan	A strategic assessment of counter seasonal NTAE markets	Purdue
3	Sandra Graces	F	Ecuador	Plant Pathology	Ecuador	Ph.D.	Sep. 01	Jun. 04	100%			Ohio State

Caribbean Region

No	Student Name	Sex	Nationality	Discipline	Site / Country	Degree	Start Date	Comp. Date	IPM CRSP Fund	Advisor/ PI	Thesis Topic	University

Africa Region

No	Student Name	Sex	Nationality	Discipline	Site / Country	Degree	Start Date	Comp. Date	IPM CRSP Fund	Advisor/ PI	Thesis Topic	University
4	Jackline Bonabana	F	Uganda	Ag. Economics	Uganda	M.S.	Aug. 00	May 02	100%	D. Taylor, V. Kasenge	Socioeconomic assessment of IPM CRSP technoloies in Uganda	Virginia Tech
5	Eric Kagezi	M	Uganda	Entomology	Uganda	M.S.	Oct. 00	Oct. 02	100%	S. Kyamanywa, R. Hammond	Thrips and Tomato Yield Relationship	Makerere
6	Magdalene Ogwang	F	Uganda	Ag. Ext.	Uganda	M.S.	Oct. 01	Oct. 03	50%	A. Semana, M. Erbaugh	Factors affecting adoption of IPM practices on cowpea	Makerere
7	Godfrey Asea	M	Uganda	Plant Breeding	Uganda	Ph.D	Sept.01	Aug. 05	100%	R.Pratt, A.Ekwamu	Molecular marker assisted selection (MAS) for foliar pathogens of maize in Africa	OSU

8	Archileo Kaaya	M	Uganda	Plant Pathology	Uganda	Ph.D	Jan. 02	Dec. 03	100%	H. Warren, E. Adipala	Mycotoxins on maize and peanuts in Uganda	Virginia Tech
9	Basil Mugonola	M	Uganda	Agricultural Economics	Uganda	M.S.	Oct. 00	Dec. 02	100%	V.Kasenge, D. Taylor	Price Risk and IPM Technology consideration in cowpea in Uganda	Makerere
10	Anthony M. Mugoya	M	Uganda	Entomology	Uganda	M.S	Oct. 01	Dec. 03	100%	S. Kyamanywa, R. Hammond	Impact of Predators and Parasitoids of Major Insect Pests on Groundnut	Makerere
11	G. Lubadde	M	Uganda	Plant Pathology	Uganda	M.S.	Oct. 01	Dec. 03	100%	E. Adipala	Epidiomiology of Coffee Wilt	Makerere
12	J.M.K. Mulema	M	Uganda	Plant Pathology	Uganda	M.S.	Oct 01	Dec. 03	100%	E. Adipala	Etiology of Coffee Wilt	Makerere
13	Stuart Gordon	M	USA	Plant Breeding	USA/Ugan	M.S.	Sep. 99	Dec. 01	75%	Richard Pratt	QTL for Gray Leaf Spot Resistance in Maize	Ohio State Univesity
14	Mountaga Kayentao	M	Malian	Weed science	Mali	DEA (Master)	2000	2001	yes	Dale Hess ICRISAT/Bouréma DEMBELE, IER	Méthodes de sélection indirectes pour l'amélioration de la lutte intégrée contre *Striga hermonthica* au Mali	Université du Mali
15	Alfouseini Ba	M	Malian	Socio-Economy	Mali	DEA (Master)	2000	2001	yes	Denis Dougnon, IFSRA/Keith Moore, VT	Socio-Economic Evaluation of IPM Technologies	Université du Mali
16	Bright Abonuhi	M	Ghanaian	Ag. Econ.	USA	M.S.	Aug. 01	May 03	Yes?	Anthony Yeboah	To be determined	NC A&T

Asia Region

No	Student Name	Sex	Nationality	Discipline	Site / Country	Degree	Start Date	Comp. Date	IPM CRSP Fund	Advisor/ PI	Thesis Topic	University
17	Chowdury S. Mohamoud	M	Bangladesh	Agric Economics	Bangladesh	Ph.D.	Sept. 99	Sep. 02	100%	G. Shively	On-farm Econ. Impacts of Crop Diversification and IPM adoption in Bangladesh	Purdue

18	Md Faruque-uz-zaman	M	Bangladesh	Entomology	Bangladesh	M.S.	Jul. 01	Sep. 03	100%	Ed Rajotte	N/A	Penn State
19	Mossammat S. Nahar	F	Bangladesh	Plant Pathology	Bangladesh	Ph.D.	Jul. 01	Sep. 03	100%	S. Miller	N/A	Ohio State
20	Nazrul Islam	M	Bangladesh	Weed Science	Bangladesh	Ph.D.	Jun. 01	Dec. 04	100%	A. Baltazar	N/A	UPLB
21	Irene Tanzo	F	Philippines	Rural Sociology	Philippines	Ph.D.	Jan. 01	Jun 04	100%	C. Sachs	N/A	Penn State
22	Virginia Recta	F	Philippines	Statistics	Philippines	Ph.D	Aug. 96	Jun 01	50%	D. Rosenberg and E. Rajotte	Analysis of Semicontinuous Spatial Data	Penn State
23	Cezar Mamaril	M	Philippines	Agric. Economics	Philippines	M.S.	Sep. 99	Sep. 01		G. Norton	Impacts of Biotech In Asia	Virginia Tech
24	Edwin Martin	M	Philippines	Weed Science	Philippines	Ph.D.	Jun 00	May 03	100%	A. Baltazar	To be determined	UPLB and Virginia Tech

Eastern Europe Region

No	Student Name	Sex	Nationality	Discipline	Site / Country	Degree	Start Date	Comp. Date	IPM CRSP Fund	Advisor/ PI	Thesis Topic	Universiy

Budget Tables

(Available in hard copies with the ME)

Integrated Pest Management
Collaborative Research Support Program
(IPM CRSP)

Annual Workplan
for Ninth Year
(September 29, 2001 to September 28, 2002)

Proposed International Travel Schedule for IPM CRSP Year 9 Work Plan

International Travel Table for IPM CRSP Year 9 Work Plan

Asian Site in the Philippines

Trip No.	*Number of individuals*	*Destination country(ies)*	*Duration and proposed dates**	*Function (site planning, workshop, symposium, etc.)*
1	2	Philippines	October 2001 – 1 week	Year 9 research planning and evaluation
2	1	Japan	November 11-16, 2001	Poster presentation, part of Ph.D. thesis by E.Gergon, Inter'l Soil and Root Research Symposium, Nagoya
3	7	Philippines	February 2002 – 1 week	Year 9 research evaluation and planning for Year 10
4	1	U.S.	May 2002 – 1 week	IPM CRSP Technical Committee Meeting; site coordinator
5	1	Philippines	June 2002 – 8 days	Site visit – S. K. DeDatta

Asian Site in Bangladesh

Trip No.	*Number of individuals*	*Destination country(ies)*	*Duration and proposed dates**	*Function (site planning, workshop, symposium, etc.)*
1	6	Bangladesh	1 week, late January	Review research progress, research planning, farmer field day
2	2	Bangladesh	2 weeks	Research, including student research
3	2	U.S. (From Bangladesh)	May, 2000 1 week	Participate in planning workshop and symposium at Virginia Tech
4	2	Bangladesh	1 week, late September	Research review and planning
5	1	Taiwan (From Bangladesh)	2 months	Short-term training
6	2	U.S. (From Bangladesh)	2 months	Short term training
7	1	Philippines (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	Jamaica, other CARDI sites	5-7 days each	Site chair research oversight and coordination, work plan development
3	1	Caribbean	1 week	PROCARIBE interaction and TC meeting
4-5	2	Jamaica	Spring, summer 2002 – 1 week	Research collaborations for vegetable IPM and Web GIS; Work plan review.
5-6	2	Jamaica	Spring 2002 – 1 week	Research collaborations on broad mite, pesticides and biocontrol; Workplan review.
7-9	1	Jamaica, Antigua, St. Kitts	Fall 2001 and Spring 2002 - 3 trips, 4-6 days	Research collaboration on sweetpotato IPM; Regionalization of IPM to other Caribbean nations
10	1	Peru	Fall 2001 – 1 week	Collaborative research planning with CIP; communication of research results at international meeting
11-12	2 (Jamaican)	St Vincent, St Lucia, Antigua, St Kitts	3-4 days each, dates TBA	Regionalization of IPM to other Caribbean nations
13	2	U.S.	1 week – May 2002	IPM CRSP planning workshop and symposium

*Proposed dates may change depending on changing circumstances

African Site in Mali

Trip No.	*Number of individuals*	*Destination country(ies)*	*Duration and proposed dates**	*Function (site planning, workshop, symposium, etc.)*
1	1 (Florence Dunkel)	Mali	2 weeks in late October-early November	Field observations and research collaboration
2	1(Jim Westwood)	Mali	1 week in November	Field observations, research collaboration, and planning
3	1 (Colette Harris)	Mali	3 weeks in Nov. /Dec.	Training
4	1(Anthony Yeboah)	Mali	2 weeks in December	Field observations and research collaboration
5	3 (Don Mullins, Jean Cobb, Pat Hipkins)	Mali	2 weeks in December-January	Training, field observations and participatory assessment
6	1 (Rick Foster)	Mali	2 weeks in January	Paper development and research collaboration
7	1 (Keith Moore)	Mali	2 weeks in March-April	Research collaboration and site planning
8	1 (Colette Harris)	Mali	1 week in April	Training and research collaboration
9	2(Mousa Ndiaye, Aissata Théra)	USA	2 weeks in May	Site Planning, research collaboration, and training
10	2 (Halima Traoré, Safiatou Berthé)	USA	3 weeks in May	Training
11	2 (Rick Foster, Bob Gilbertson)	Mali	2 weeks in June	Research collaboration and field observations
12	1 (Colette Harris)	Mali	1 week in July	Training and research collaboration
13	3 (Don Mullins, Jean Cobb, Pat Hipkins)	Mali	2 weeks in August-September	Training and field observations

*Proposed dates may change depending on changing circumstances

African Site in Uganda

Trip No.	*Number of individuals*	*Destination country(ies)*	*Duration and proposed dates**	*Function (site planning, workshop, symposium, etc.)*
1	1 (Asea, MU)	USA (OSU)	September, 2001	To begin doctoral program.
2	1 (Pratt, OSU)	S. Africa	5 days 10/1-10/6, 2001	To meet with South African scientists collaborating on marker selection of maize diseases (to be cost shared with another project).
3	2 (Warren VT, Erbaugh, OSU)	Uganda	10 days 10/5- 10/15, 2001	Annual Report preparation, coffee wilt research implementation.
4	1 (Hakiza, NARO)	USA (OSU)	2 mos. 9/10 – 11/10, 2001	Etiology of coffee wilt.
5	1 (Ochwo, MU)	USA (OSU)	2 mos. –8/27 – 10/27	Potato Late Blight Characterization (To be cost shared with Rockefeller Forum).
6	1 (Hammond, OSU)	Uganda	10 days, 11/11 – 11/19	Field Data Collection on cowpea, ground nuts, and tomato.
7	1 (Bonabana,VT)	Uganda	January, 2001	To initiate data collection for M.S. thesis.
8	1 (Kaaya, MU)	USA (VT)	January, 2002	To begin course work for doctoral program.
9	6 (Brhane, Taylor, Warren, Luther,VT; Erbaugh, Hammond OSU; Mbata, FVSC)	Uganda	9 days, late Feb. early March, 2002	Annual work plan development meeting, data analysis
10	2 (Kyamanywa, MU)	USA	7-10 days, May, 2002	Attend annual IPM CRSP meetings.
11	1 (Luther, VT).	Uganda	10 days, late May, 2002	Beneficial insects of cowpea and groundnuts.
12	2 (Grossman and other, VT)	Uganda	9 days, early June, 2002	Conduct GIS workshop.
13	2 (Lipps/ Pratt, and Erbaugh, OSU)	Uganda	12 days, late June, 2002	Data Collection, field trial assessment.

*Proposed dates may change depending on changing circumstances

Latin American Site in Guatemala

Trip No.	***Number of individuals***	***Destination country(ies)***	***Duration and proposed dates****	***Function (site planning, workshop, symposium, etc.)***
1	2	Guatemala	October – 7-10 days	Program planning and development, research collaborator meetings and site visits
2	3	Guatemala	November – 7-10 days	Research collaborations and activity planning
3	1	Guatemala	December – 14 days	Field data collection
4	2	Guatemala	February – 10 days	Research work with collaborators
5	4	Guatemala, Honduras and Nicaragua	February/March – 14 days	Research collaborations, program planning and development, and regional expansion meetings.
6	2	Guatemala	April – 7 days	Research work with collaborators
7	1	USA	May 2002, 7 Days	Planning workshop
8	5	Guatemala	June – 10-14 days	Research work with collaborators, field data collection, work plan finalization, annual reports discussion, possible IPM Workshop
9	1	Guatemala	August – 7-10 days	Field data collection and analysis

*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 23-October 28, 2001	Research Collaboration
2	2	Ecuador	October 15-21	Research Collaboration and Site Planning
3	2	Ecuador	Mid October 2001, 10 days	Research Collaboration
4	1	Ecuador	January 2002, 20 Days	Research Collaboration
5	1	Ecuador	February 2002, 15 Days	Research Collaboration
6	1	Ecuador	March/April 2002, 30 Days	Research Collaboration
7	2	USA	May 2002, 7 Days	Planning workshop
8	1	Ecuador	Summer 2002, 30 Days	Research Collaboration

*Proposed dates may change depending on changing circumstances

Eastern Europe/NIS Site in Albania

Trip No.	***Number of individuals***	***Destination country(ies)***	***Duration and proposed dates****	***Function (site planning, workshop, symposium, etc.)***
1	1(D. Pfeiffer)	Albania	2 trips of 2 weeks, spring and fall	Coordination, initiation, and completion of research, emphasizing entomological experiments
2	1(C. Pitts)	Albania	1 trip of 2 weeks, spring or fall	Coordination, initiation, and completion of research
3	1(B.Teviotdale)	Albania	1 trip of 2 weeks, spring or fall	Coordination, initiation, and completion of research, emphasizing phytopathological experiments
4	1(L. Ferguson)	Albania	1 trip of 2 weeks, spring or fall	Coordination, initiation, and completion of research, emphasizing horticultural experiments
5	1(M. McGiffen)	Albania	1 trip of 2 weeks, spring or fall	Coordination, initiation, and completion of research, emphasizing vegetation management experiments
6	1(L. Daku)	Albania	1 trip of 2 weeks	Coordination, initiation, and completion of research, emphasizing agricultural economical issues
7	2 (Albanian Co-PIs)	USA	One trip in May, 1-1.5 weeks	Albanian scientists to attend CRSP planning workshop held in Blacksburg
8	2 scientists	Albania	1 week	Statisticians for follow-up statistical training for Albanian scientists

*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	1	Mali	1 week in August / September	Review research progress
3	2	Bangladesh / Philippines	October / January	Review research activities, farmer field day
4	1	Bangladesh	1 week in May / June	PL 480 follow up
5	2	Guatemala	December/February	Review research activities
6	2	Ecuador	January / September	Review research activities
7	1	Caribbean	June	PROCICARIBE Regional IPM network TC meeting
8	2	Albania	April / November	Review research activities

*Proposed dates may change depending on changing circumstances